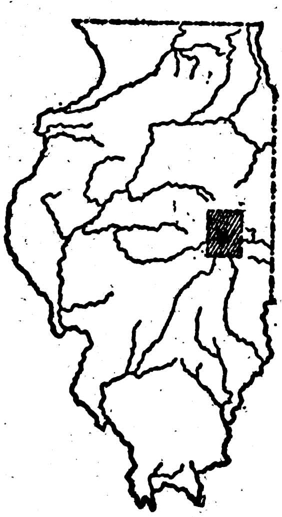
UNIVERSITY OF ILLINOIS

Agricultural Experiment Station

SOIL REPORT NO. 18

CHAMPAIGN COUNTY SOILS

BY CYRIL G. HOPKINS, J. G. MOSIER,
E. VAN ALSTINE, AND F. W. GARRETT



URBANA, ILLINOIS, NOVEMBER, 1918

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INTRODUCTORY NOTE

About two-thirds of Illinois lies in the corn belt, where most of the prairie lands are black or dark brown in color. In the southern third of the state, the prairie soils are largely of a gray color. This region is better known as the wheat belt, altho wheat is often grown in the corn belt and corn is also a common crop in the wheat belt.

Moultrie county, representing the corn belt; Clay county, which is fairly representative of the wheat belt; and Hardin county, which is taken to represent the unglaciated area of the extreme southern part of the state, were selected for the first Illinois Soil Reports by counties. While these three county soil reports were sent to the Station's entire mailing list within the state, subsequent reports are sent only to those on the mailing list who are residents of the county concerned, and to anyone else upon request.

Each county report is intended to be as nearly complete in itself as it is practicable to make it, and, even at the expense of some repetition, each will contain a general discussion of important fundamental principles, in order to help the farmer and landowner understand the meaning of the soil fertility invoice for the lands in which he is interested. In Soil Report No. 1, "Clay County Soils," this discussion serves in part as an introduction, while in this and other reports it will be found in the Appendix; but if necessary it should be read and studied in advance of the report proper.

CHAMPAIGN COUNTY SOILS

By CYRIL G. HOPKINS, J. G. MOSIER, E. VAN ALSTINE, AND F. W. GARRETT

Champaign county is located in the east-central part of Illinois, about 22 miles from the Indiana line and 140 miles from the north end of the state. The county is approximately 36 miles long and 27 miles wide, and contains 988 square miles, of which 99.7 percent, or all but three square miles, is tillable land. Not all of this tillable land, however, has been put under cultivation, some areas being still undrained or uncleared. In topography the land varies from flat to slightly rolling, with a few small areas along streams that are too steep to be cultivated. The difference in topography is due to two causes—glacial action and stream erosion.

Champaign county was covered by two ice sheets during the Glacial period. At that time snow and ice accumulated in the region of Labrador and to the west of Hudson Bay to such an amount that it pushed outward from these centers, especially southward, until a point was reached where the ice melted as rapidly as it advanced. In moving across the country, the ice gathered up all sorts and sizes of material, including clay, silt, sand, gravel, boulders, and even large masses of rock. Many of these materials were carried for hundreds of miles and rubbed against surface rocks or against each other until ground into sand and silt. When, thru the melting of the ice, the limit of advance was reached, this transported material accumulated in a terminal moraine, a broad undulating ridge, usually with a steep outer slope and with the inner slope longer and more gradual. The width of these moraines varies from a half mile to three or four miles. When the ice melted away more rapidly than the glacier advanced, the terminus of the glacier would recede and leave this material deposited somewhat uniformly over the area previously covered by the ice sheet. The glacier advanced and receded a number of times, and with each advance another moraine was formed. The intervening intermorainal tracts are now occupied chiefly by level, undulating, or slightly rolling plains.

The material transported by the glacier varied with the character of the rocks over which it passed. Granites, limestones, sandstones, shales, et cetera, were mixed, and ground up together. This mixture of all kinds of material—boulders, clay, silt, sand, and gravel—is called boulder clay, till, glacial drift, or simply drift. The grinding and denuding power of glaciers is enormous. A mass of ice 100 feet thick exerts a pressure of 40 pounds per square inch, and this ice sheet may have been several thousand feet in thickness. The materials carried along in this mass of ice, especially the boulders and pebbles, became powerful agents for grinding and wearing away the surface over which the ice passed. Preglacial ridges and hills were rubbed down, valleys were filled with the debris, and the surface features were changed entirely.

Plate 1.—A Large Limestone Boulder that Traveled over 100 Miles with the Glacier

Champaign county was first covered by the Illinois glacier, which did its share toward leveling the region and covering it with a deposit of boulder clay. After this glaciation a long period elapsed, during which a soil now known as the Sangamon soil, was formed from this glacial deposit. Later a large part of the state, including all of Champaign county, was covered with a deposit of wind-blown material, called loess, which buried the old Sangamon soil that was formed from the Illinois glacial drift. The loess varied from a few feet to 100 feet in thickness, but in this county it was probably not over 10 feet thick. A new soil was formed from the loess, and this is called the Peorian soil. After a long period had again elapsed, another ice advance occurred—the early Wisconsin glacier. This covered the entire county, bringing with it immense quantities of material, which buried the loess and the Peorian soil.

The deepest total deposit of boulder clay in the county is at Champaign, where a boring showed 300 feet. The thinnest drift so far found is at Sidney, where it is 95 feet thick. The average depth over the county is 200 feet. This includes both Illinoisan and Wisconsin drift and loessial strata. Boulders are quite common in the drift and some are very large (see Plate 1). A few miles southeast of Philo, in Section 4, Township 17 North, Range 10 East, a very large mass of limestone occurs, 16 feet square, extending some distance below the surface. Other large masses are found in the same region. The Shelbyville moraine marks the outward limit of the early Wisconsin glacier. The Peorian soil which was buried by the last glacier, is found at depths varying from 60 to 100 feet. The Peorian soil itself varies from black soil to compressed peat or muck. No rock outcrop occurs in the county.

The Wisconsin glacier advanced and receded several times, each advance forming a distinct moraine. The Cerro Gordo moraine starts in this county near Mahomet and extends into Piatt county to the southwest, southeast of the Sangamon river. This is probably the oldest moraine in the county. The Champaign morainic system crosses the county in a general northwest-southeast direction. It enters the county north of Mahomet at the corner of McLean county. It divides at Champaign, one branch extending south and the other southeast, forming Yankee ridge. South of Sidney, the Yankee ridge divides, forming two ridges, one just south of Homer and the other north of Broadlands. Another very high ridge, a part of the Bloomington morainic system, crosses the northeast part of the county, extending northwest and southeast. Between these ridges are broad, flat to slightly undulating plains, much of which was swampy and has been artificially drained.

PHYSIOGRAPHY AND DRAINAGE

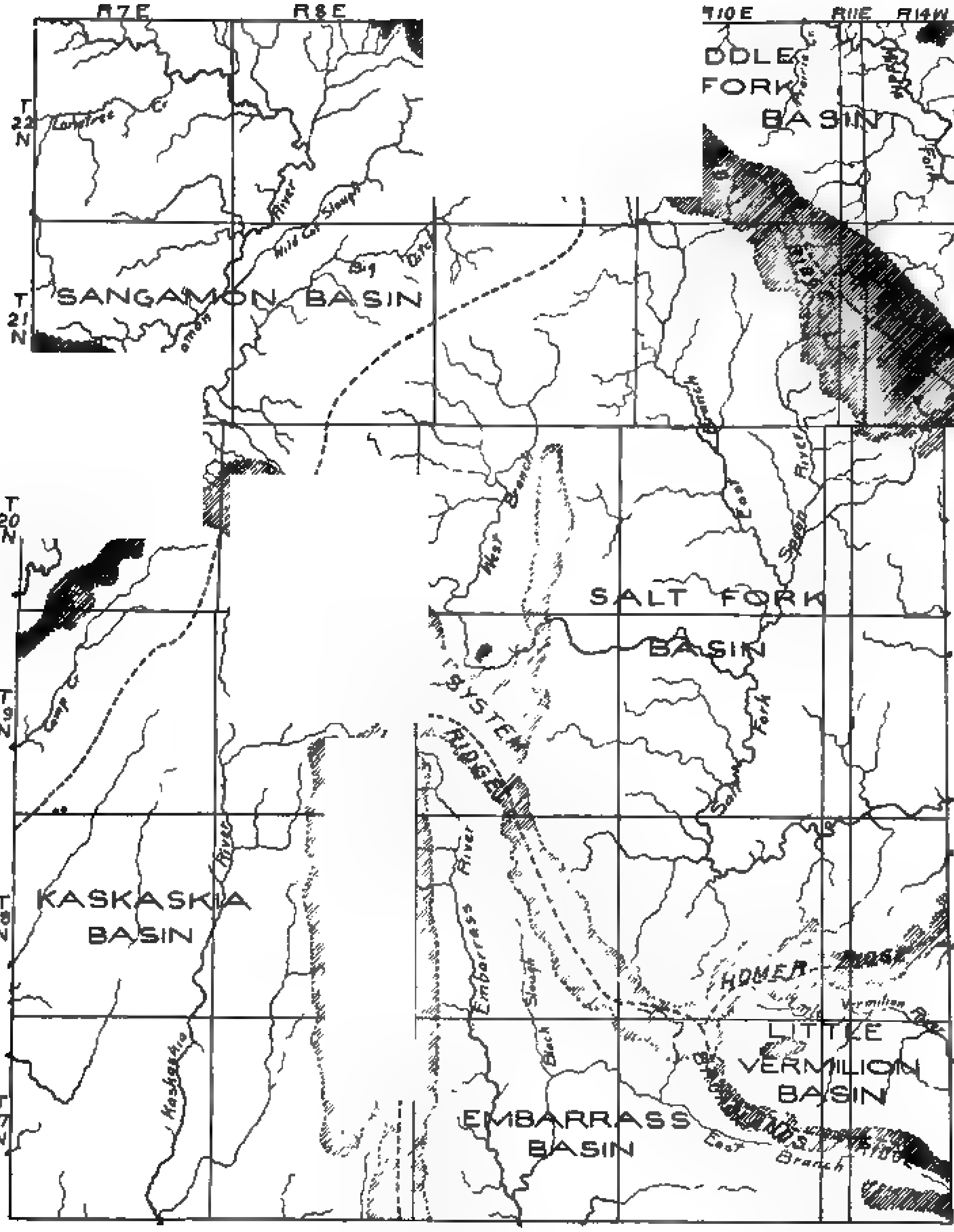
The altitude of Champaign county above sea level varies from 860 feet on the Champaign moraine north of Rising, to about 630 feet where the Salt Fork leaves the county northeast of Homer. The average altitude is about 710 feet. The altitudes of some other places in the county are as follows: Block, 715 feet; Bondville, 716; Bongard, 678; Broadlands, 680; Champaign, 740; Deers, 692; Dewey, 736; Dickerson, 757; Dillsburg, 750; Fisher, 732; Foosland, 734; Gifford, 810; Homer, 661; Howard, 741; Ivesdale, 683; Leverett, 736; Longview, 674; Ludlow, 773; Mahomet, 712; Mayview, 686; Ogden, 675; Penfield, 725; Pesotum, 720; Philo, 737; Rantoul, 758; Rising, 734; Sadorus, 692; Savoy, 740; Seymour, 697; St. Joseph, 673; Sidney, 672; Thomasboro, 736; Tipton, 673; Tolono, 736; Urbana, 721.

The county is divided into six drainage areas, as follows:

(1) The Sangamon basin (see Plate 2) includes the northwestern part of the intermorainal tract between the Champaign and Bloomington moraines. This basin is drained by the Sangamon river, which breaks thru the Champaign moraine near Mahomet. The Sangamon drains very little land south of the Champaign moraine because the Cerro Gordo ridge lies just east of the river valley and cuts off any streams from that direction.

(2) The Kaskaskia basin (the southwestern area) is drained by the Kaskaskia river and its tributaries. The east watershed is formed by the outer or west ridge of the Champaign moraine, the Savoy ridge, which extends south into Douglas county. In Champaign county this ridge forms the divide between the Embarrass and the Kaskaskia rivers, or between the Ohio and the Mississippi river systems.

(3) The Embarrass ("Ambraw") basin (the southeastern area) is drained by the Embarrass river and its branches, which include the Black Slough and East Branch. The latter rises in Vermilion county near Sidell and unites with the main stream about three-fourths of a mile north of the southern county line. To the north, the eastern side of the watershed is formed by the Yankee ridge, a part of the Champaign moraine. South of Sidney the ridge divides into the Homer and Broadlands ridges. The Broadlands branch forms the northern divide of the East Branch of the Embarrass.



MAP SHOWING THE MORAINES AND DRAINAGE BASINS OF CHAMPAIGN COUNTY, WITH APPROXIMATE MORAINIC BOUNDARIES. THE BROKEN LINES SHOW THE DIVIDES

(4) The Little Vermilion basin lies between the Homer and Broadlands ridges. This basin is drained by the Little Vermilion river, which flows eastward into Indiana, emptying into the Wabash river.

(5) The large Salt Fork basin lies between the Yankee ridge and the Gifford ridge, a part of the Bloomington morainic system, and extends from the east line of the county to a low ridge running southwest from Rantoul to the Champaign moraine east of Mahomet. This drainage area is comparatively flat, as is indicated by the large amount of black clay loam.

(6) The Middle Fork basin, lying in the northeast part of the county, is drained by Middle Fork of the Vermilion river. This stream is peculiar in that it has formed considerable areas of gravel terrace.

The glacial deposits with the variable beds of sand and gravel furnish the county an abundance of good water. Two small areas, one immediately northwest of St. Joseph and the other near Penfield, furnish flowing wells.

Soil Material and Soil Types

The early Wisconsin glacier left extensive deposits of boulder clay over the county, but the soils as a rule are not formed from this material. The fine material of the glacial drift was reworked by water and wind action, resulting in the deposition of several feet of fine material of loessial character, and from this the soils were formed. Originally this loessial deposit was very likely of more nearly uniform thickness, but subsequent erosion has removed a large part from the more rolling areas, where the loess now varies from 0 to 3 feet in thickness, and increased its depth in the lower-lying land which received the deposit, where now it may be from 6 to 8 feet deep.

The soils of the county are divided into four classes, as follows:

(a) Upland prairie soils, rich in organic matter. These were originally covered with wild prairie grasses, the partially decayed roots of which have been the source of the organic matter. The flat prairie land contains a higher amount of this constituent than the undulating or rolling prairie, because the grasses and roots grew more luxuriantly there, and the higher moisture content preserved them from complete decay.

The upland prairie soils include some areas of recent timber growth where certain kinds of trees have spread over the prairie, but this forestation has not been of sufficient duration to produce the characteristic timber soils. These areas of greater or less width are found along the border of most timber tracts, so that the timber actually extended a little farther than the soil type would indicate. A good illustration is found in Section 31, southeast of Philo. A grove locally known as Lynn Grove was started on the moraine, and altho the forest now covers 120 acres, yet it has not been there long enough to change the character of the soil. This indicates that several generations of trees would be necessary to change the soil type.

(b) Upland timber soils, including those zones along stream courses over which for a long period of time forests once extended. These soils contain much less organic matter than the prairie soils because the large roots of dead trees and the surface accumulations of leaves, twigs, and fallen trees were burned by forest fires or suffered almost complete decay. The timber lands are divided chiefly into two subclasses—the undulating and the hilly areas.

(c) Terrace soils, formed by deposits from flooded streams overloaded with coarse sediment, perhaps at the time of the melting of the glacier. Finer deposits which were later made upon the coarse, gravelly material now constitute the soil. Terrace soils were generally covered by forests.

(d) Swamp and bottom lands, which include the flood plains along streams and some small peaty swamp areas.

Table 1 gives the area of each type of soil in Champaign county and its percentage of the total area. It will be observed that 92.2 percent of the area consists of upland prairie soil, 4.89 percent of upland timber soil, .52 percent of terrace soil, and 2.39 percent of swamp and bottom-land soils. The accompanying maps show the location and boundary lines of every type of soil on every farm in the county, even down to areas of a few acres.

TABLE 1.—SOIL TYPES OF CHAMPAIGN COUNTY, ILLINOIS

Soil type No.	Name of type	Area in square miles	Area in acres	Percent of total area
	(a) Upland Prairie Soils (900, 1100), page 27			
926, 1126	Brown silt loam	720.00	460 800	72.86
920, 1120	Black clay loam	176.47	112 941	17.86
1121	Drab clay loam	9.58	6 131	.97
928, 1128	Brown-gray silt loam on tight clay	4.11	2 630	.42
1160	Brown sandy loam	.87	557	.09
		911.03	583 059	92.20
	(b) Upland Timber Soils (900, 1100), page 36			
934, 1134	Yellow-gray silt loam	45.16	28 902	4.57
935, 1135	Yellow silt loam	3.06	1 958	.31
1164	Yellow-gray sandy loam	.11	70	.01
		48.33	30 930	4.89
	(c) Terrace Soils (1500), page 44			
1527	Brown silt loam over sand or gravel	2.41	1 542	.24
1536	Yellow-gray silt loam over sand or gravel	2.71	1 734	.27
1560	Brown sandy loam	.07	45	.01
		5.19	3 322	.52
	(d) Swamp and Bottom-Land Soils (1400), page 45			
1454	Mixed loam	23.43	14 995	2.37
1401	Deep peat	.14	90	.02
1402	Medium peat on clay	.03	19	.003
		23.60	15 104	2.39
	Total	988.15	632 415	100.00

THE INVOICE AND INCREASE OF FERTILITY IN CHAMPAIGN COUNTY SOILS

SOIL ANALYSIS

In order to avoid confusion in applying in a practical way the technical information contained in this report, the results are given in the most simplified form. The composition reported for a given soil type is, as a rule, the average analysis of many soil samples, which, like most things in nature, show more or less variation; but for all practical purposes the average is most trustworthy and

sufficient.[1] (See Bulletin 123, which reports the general soil survey of the state, together with many hundred individual analyses of soil samples representing twenty-five of the most important and most extensive soil types in the state.)

The chemical analysis of a soil gives the invoice of fertility actually present in the soil strata sampled and analyzed, but, as explained in the Appendix, the rate of liberation is governed by many factors. Also, as there stated, probably no agricultural fact is more generally known by farmers and landowners than that soils differ in productive power. Even tho plowed alike and at the same time, prepared the same way, planted the same day with the same kind of seed, and cultivated alike, watered by the same rains and warmed by the same sun, nevertheless the best acre may produce twice as large a crop as the poorest acre on the same farm, if not, indeed, in the same field; and the fact should be repeated and emphasized that the productive power of normal soil in humid sections depends upon the stock of plant food contained in the soil and upon the rate at which it is liberated.

The fact may be repeated, too, that crops are not made out of nothing. They are composed of ten different elements of plant food, every one of which is absolutely essential for the growth and formation of every agricultural plant. Of these ten elements of plant food, only two (carbon and oxygen) are secured from the air by all plants, only one (hydrogen) from water, while seven are secured from the soil. Nitrogen, one of these seven elements secured from the soil by all plants, may also be secured from the air by one class of plants (legumes) in case the amount liberated from the soil is insufficient. But even the leguminous plants (which include the clovers, peas, beans, alfalfa, and vetches), in common with other agricultural plants, secure from the soil alone six elements (phosphorus, potassium, magnesium, calcium, iron, and sulfur) and also utilize the soil nitrogen so far as it becomes soluble and available during their period of growth.

Table A in the Appendix shows the requirements of large crops for the five most important plant-food elements which the soil must furnish. (Iron and sulfur are supplied normally from natural sources in sufficient abundance, compared with the amounts needed by plants, so that they are never known to limit the yield of common farm crops.)

In Table 2 are reported the amounts of organic carbon (the best measure of the organic matter) and the total amounts of the five important elements of plant food contained in 2 million pounds of the surface soil of each type in Champaign county—the plowed soil of an acre about 6⅔ inches deep. In addition, the table shows the amount of limestone present, if any, or the soil acidity as measured by the amount of limestone required to neutralize it.

The soil to the depth indicated includes at least as much as is ordinarily turned with the plow, and represents that part with which the farm manure, limestone, phosphate, or other fertilizer applied in soil improvement is incorporated. It is the soil stratum that must be depended upon in large part to furnish the necessary plant food for the production of crops, as will be seen from the information given in the Appendix. Even a rich subsoil has little or no value if it lies beneath a worn-out surface, for the weak, shallow-rooted plants will

[1]For types of very limited extent, or of quite variable character ("mixed"), only one set of samples, or samples representing only the most common phase, may be collected for analysis, and such analyses have, of course, less application.

be unable to reach the supply of plant food in the subsoil. If, however, the fertility of the surface soil is maintained at a high point, then the plants, with a vigorous start from the rich surface soil, can draw upon the subsurface and subsoil for a greater supply of plant food.

By easy computation it will be found that the most common upland soil of Champaign county, the brown silt loam prairie, does not contain more than enough total nitrogen in the plowed soil for the production of maximum crops for nine rotations (36 years).

With respect to phosphorus, the condition differs only in degree, this most important upland soil of the county containing no more of that element than would be required for fourteen crop rotations if such yields were secured as are suggested in Table A of the Appendix. It will be seen from the same table that in the case of the cereals about three-fourths of the phosphorus taken from the soil is deposited in the grain, while only one-fourth remains in the straw or stalks.

On the other hand, the potassium in this common soil type is sufficient for 28 centuries if only the grain is sold, or for more than 400 years even if the total crops should be removed and nothing returned. The corresponding figures are about 2,400 and 550 years for magnesium, and about 10,500 and 250 years for calcium. Thus, when measured by the actual crop requirements for plant food, potassium is no more limited than magnesium and calcium; and, as explained in the

TABLE 2.—FERTILITY IN THE SOILS OF CHAMPAIGN COUNTY, ILLINOIS
Average pounds per acre in 2 million pounds of surface soil (about 0 to 6⅔ inches)

Soil type No.	Soil type	Total organic carbon	Total nitrogen	Total phosphorus	Total potassium	Total magnesium	Total calcium	Limestone present	Soil acidity present
	Upland Prairie Soils (900, 1100)								
926 1126	Brown silt loam...	56 160	4 670	1 060	35 430	9 550	10 680		40
920 1120	Black clay loam...	73 620	6 750	1 780	34 060	14 410	18 330	Often	Often
928 1128	Brown-gray silt loam on tight clay	38 860	3 630	1 140	29 930	6 040	5 080		570
1121	Drab clay loam....	55 450	5 220	1 460	37 040	14 920	16 560	Often	Often
1160	Brown sandy loam.	29 540	2 520	840	26 840	4 060	6 560		120
	Upland Timber Soils (900, 1100)								
934 1134	Yellow-gray silt loam............	25 200	2 350	930	35 070	6 650	7 430		30
935 1135	Yellow silt loam...	17 360	1 200	860	35 320	5 500	6 480		20
1164	Yellow-gray sandy loam............	20 020	1 340	740	29 180	3 440	5 900		20
	Terrace Soils (1500)								
1536	Yellow-gray silt loam over sand or gravel...........	23 880	2 190	1 090	36 440	6 540	6 670		50
1527	Brown silt loam over sand or gravel	41 960	4 020	1 180	36 300	8 180	7 860		40
1560	Brown sandy loam.	69 660	6 220	1 500	31 100	6 720	11 220		20
	Swamp and Bottom-Land Soils (1400)								
1454	Mixed loam.......	61 840	5 530	1 660	41 570	17 720	23 400		Often
1401	Deep peat[1].......	258 990	24 510	1 370	7 950	6 310	72 180	102 180	
1402	Medium peat on clay[1]...........	198 200	17 010	840	13 080	6 310	16 370		40

[1]Amounts reported are for 1 million pounds of deap peat and medium peat.

Appendix, with magnesium, and more especially with calcium, we must also consider the fact that loss by leaching is far greater than by cropping.

These general statements relating to the total quantities of plant food in the plowed soil of the most prevalent type in the county certainly emphasize the fact that the supplies of some of these necessary elements of fertility are extremely limited when measured by the needs of large crop yields for even one or two generations of people.

The variation among the different types of soil in Champaign county with respect to their content of important plant-food elements is also very marked. The deep peat contains in the plowed soil of an acre twenty times as much nitrogen as the yellow silt loam, and about five times as much nitrogen but only one-fourth as much potassium as the brown silt loam. The total supply of phosphorus in the surface soil varies from 740 pounds per acre in the yellow-gray sandy loam to 1,780 pounds in the black clay loam. The magnesium and calcium vary from about 4,000 and 5,000 pounds in the lighter soils to about 20,000 pounds in some other types. One type contains an abundance of limestone, while some others are slightly acid in the surface, more strongly acid in the subsurface, and sometimes devoid of limestone even in the subsoil. More than 80 percent of the soils of the county contain no limestone in the surface or subsurface to a depth of 20 inches.

With an inexhaustible supply of nitrogen in the air and with 35,000 pounds of potassium in the most common prairie soil, the economic loss in farming such land with some acidity and with only 1,060 pounds of total phosphorus in the plowed soil can be appreciated only by the man who fully realizes that in less than one generation the average crop yields could be doubled by the proper use of limestone and phosphorus in rational farm systems, without change of seed or season and with very little more work than is now devoted to the fields. Fortunately, some definite field experiments have already been conducted on this most extensive type of soil on the University experiment fields in several counties, as at Urbana in Champaign county, at Sibley in Ford county, at Bloomington in McLean county, and for shorter periods in some other counties. Before considering in detail the individual soil types, it seems advisable to study some of the results already obtained where definite systems of soil improvement have been tried out on some of these experiment fields in different parts of central Illinois.

RESULTS OF FIELD EXPERIMENTS AT URBANA

A three-year rotation of corn, oats, and clover was begun on the North Farm at the University of Illinois in 1902, on three fields of typical brown silt loam prairie land which, after twenty years or more of pasturing, had grown corn in 1895, 1896, and 1897 (when careful records were kept of the yields produced), and had then been cropped with clover and grass on one field (Series 100), oats on another (Series 200), and oats, cowpeas, and corn on the third field (Series 300) until 1901. From 1902 to 1910 the three-year rotation (with cowpeas in place of clover in 1902) was followed. The average yields are recorded in Table 3.

A small crop of cowpeas in 1902 and a partial crop of clover in 1904 constituted all the hay harvested during the first rotation, mammoth clover grown in

PLATE 2.—CLOVER IN 1913 ON URBANA FIELD
FARM MANURE APPLIED
YIELD, 1.43 TONS PER ACRE

1903 having lodged so that it was plowed under. The average yields of hay shown in the table represent one-third of the two small crops.

From 1902 to 1907 legume cover crops (Le), such as cowpeas and clover, were seeded in the corn at the last cultivation on Plots 2, 4, 6, and 8, but the growth was small and the net effect, if any, was to decrease the returns from the regular crops. Since 1907 crop residues (R) have been returned to those plots. These consist of the stalks of corn, the straw of small grains, and all legumes except alfalfa hay and the seed of clover and soybeans, including since 1911 (except when alfalfa follows wheat) a legume cover crop (usually sweet clover) seeded on the young wheat and plowed under the next spring for corn.

On Plots 3, 5, 7, and 9, manure (M) was applied for corn at the rate of 6 tons per acre during the second rotation, and subsequently for each rotation as many tons of manure are applied for corn as there have been tons of air-dry produce harvested from the corresponding plots.

Lime (L) was applied on Plots 4 to 10 at the rate per acre of 250 pounds of air-slaked lime in 1902 and 600 pounds of limestone in 1903. Subsequently 2 tons per acre of limestone were applied to these plots on Series 100 in 1911, on Series 200 in 1912, on Series 300 in 1913, and on Series 400 in 1914; also 2½ tons per acre on Series 500 in 1911, two more fields having been brought into rotation, as explained on the following page.

PLATE 3.—CLOVER IN 1913 ON URBANA FIELD
FARM MANURE, LIMESTONE, AND PHOSPHORUS APPLIED
YIELD, 2.90 TONS PER ACRE

Phosphorus (P) has been applied on Plots 6 to 9 since 1902 at the rate of 25 pounds per acre per annum in 200 pounds of steamed bone meal; but beginning with 1908, one-half of each phosphorus plot has received 600 pounds of rock phosphate in place of the 200 pounds of bone meal, the usual practice being to apply and plow under at one time all phosphorus and potassium required for the rotation.

Potassium (K=kalium) has been applied on Plots 8 and 9 at the yearly rate of 42 pounds per acre in 100 pounds of potassium sulfate, regularly in connection with the bone meal and rock phosphate.

On Plot 10 about five times as much manure and phosphorus are applied as on the other plots, but this "extra heavy" treatment was not begun until 1906, only the usual lime, phosphorus, and potassium having been applied in previous years. These heavy applications are made in an attempt to determine the climatic possibilities in crop yields by removing the limitations of inadequate fertility.

Series 400 and 500 were cropped in corn and oats from 1902 to 1910, but the various plots were treated the same as the corresponding plots in the three-year rotation. Beginning with 1911, the five series have been used for a combination rotation; wheat, corn, oats, and clover being rotated for five years on four fields, while alfalfa occupies the fifth field, which is then brought under the four-crop

TABLE 3.—YIELDS PER ACRE, THREE-YEAR AVERAGES: URBANA FIELD
BROWN SILT LOAM PRAIRIE; EARLY WISCONSIN GLACIATION

Le = legume cover crop; L=lime; P=phosphorus; K=potassium; M=manure; x=extra heavy applications of manure and phosphorus; R=crop residues (corn stalks, straw of wheat [illegible] legumes except seed).

[1]These clover yields were printed [illegible] ne previous reports.

TABLE 4.—YIELDS PER ACRE, SEVEN-YEAR AVERAGES, 1911-17; URBANA FIELD
BROWN SILT LOAM PRAIRIE; EARLY WISCONSIN GLACIATION

Serial plot No.	Soil treatment	Wheat bu.	Corn bu.	Oats bu.	Soybeans -4, tons (bu.)	Clover -3, tons (bu.)	Alfalfa ton	Value of 5 crops Lower prices	Value of 5 crops Higher prices
1	O..........	21.9	54.0	53.0	1.60	1.60	2.12	$111.63	$156.28
2	R..........	26.3	56.1	54.5	(21.3)	(.87)	2.15	113.55	158.98
3	M..........	24.6	63.9	63.5	1.68	2.20	2.10	121.98	170.78
4	RL.........	28.3	60.2	55.8	(20.7)	(1.26)	2.33	121.25	169.76
5	ML.........	30.6	64.1	65.8	1.72	2.73	2.76	138.11	193.34
6	RLP........	42.6	67.0	72.6	(22.6)	(2.05)	3.57	162.44	227.42
7	MLP........	40.1	68.2	71.7	1.92	3.50	3.58	164.65	230.52
8	RLPK......	41.7	66.1	73.5	(24.2)	(1.38)	3.59	159.79	223.70
9	MLPK......	39.4	64.5	75.1	2.09	3.36	3.64	164.43	230.22
10	MxLPx......	42.7	62.7	76.6	2.17	3.42	3.70	168.76	236.26

system to make place for alfalfa on one of the other fields for another five-year period, and so on. (See Table 4.)

From 1911 to 1917 soybeans were substituted four years because of clover failure; accordingly four-sevenths of the soybeans and three-sevenths of the clover are used to compute values. Alfalfa from the 1911 seeding so nearly failed that after cutting one crop in 1912 the field was plowed and reseeded. The average yield reported for alfalfa in Table 4 is one-seventh of the combined crops of 1912, 1913, 1914, 1915, 1916, and 1917.

The "lower prices" allowed for produce are $1 a bushel for wheat and soybeans, 50 cents for corn, 40 cents for oats, $10 for clover seed, and $10 a ton for hay; while the "higher prices" are 40 percent more than these values, or $1.40 for wheat and soybeans, 70 cents for corn, 56 cents for oats, $14 for clover seed, and $14 a ton for hay. The two sets of values are used to emphasize the fact that a given practice may or may not be profitable, depending upon the prices of farm produce. The lower prices are conservative, and unless otherwise stated, they are the values regularly used in the discussion of results. It should be understood that the increase produced by manures and fertilizers requires increased expense for binding twine, shocking, stacking, baling, threshing, hauling, storing, and marketing. Measured by Illinois prices for the past ten years, these lower values are high enough for crops standing in the field ready for harvest.

The cost of limestone delivered at a farmer's railroad station in carload lots averages about $1.25 per ton. Steamed bone meal in carloads costs from $30 to $40 per ton. Fine-ground raw rock phosphate containing from 260 to 280 pounds of phosphorus, or as much as the bone meal contains ton for ton, but in less readily available form, usually costs the farmer from $8 to $10 per ton in carloads. (Acid phosphate carrying half as much phosphorus, but in soluble form, may cost three times as much as the raw rock, or from $24 to $30 per ton delivered in carload lots in central Illinois.) Under normal conditions potassium costs about 6 cents a pound, or $2.50 per acre per annum for the amount applied in these experiments, the same as the cost of 500 pounds of rock phosphate at $10 per ton.

To these cash investments must be added the expense of hauling and spreading the materials. This will vary with the distance from the farm to the railroad station, with the character of the roads, and with the farm force and the immedi-

PLATE 4.—CLOVER ON URBANA FIELD, SOUTH FARM
CROP RESIDUES PLOWED UNDER

ate requirements of other lines of farm work. It is the part of wisdom to order such materials in advance to be shipped when specified, so that they may be received and applied when other farm work is not too pressing and, if possible, when the roads are likely to be in good condition.

The practice of seeding legume cover crops in the cornfield at the last cultivation where oats are to follow the next year has not been found profitable, as a rule, on good corn-belt soil; but the returning of the crop residues and cover crops to the land may maintain the nitrogen and organic matter equally as well as the hauling and spreading of farm manure—and this makes possible permanent systems of farming on grain farms as well as on live-stock farms, provided, of course, that other essentials are supplied. (Clover with oats or wheat, as a cover crop to be plowed under for corn, often gives good results. Sweet clover is most promising for this purpose.)

At the lower prices for produce, manure (6 tons per acre) was worth $1.71 a ton as an average for the first three years during which it was applied (1905 to 1907). For the next rotation the average application of 10.21 tons per acre on Plot 3 was worth $14.41, or $1.41 a ton. During the next four years, 1911 to 1914, the average amount applied (once for the rotation) on Plot 3 was 11.35 tons per acre, worth $9.17, or 81 cents a ton, as measured by its effect on the

PLATE 5.—CLOVER ON URBANA FIELD, SOUTH FARM
FINE-GROUND ROCK PHOSPHATE PLOWED UNDER WITH CROP RESIDUES

wheat, corn, oats, soybeans, and clover. Thus, as an average of the ten years' results, the farm manure applied to Plot 3 has been worth $1.20 a ton on common corn-belt prairie soil, with a good crop rotation including legumes. During the last four years of this ten-year period moisture was the limiting factor to such an extent as probably to lessen the effect of the manure.

Aside from the crop residues and manure, each addition affords a duplicate test as to its effect. Thus the effect of limestone is ascertained by comparing Plots 4 and 5, not with Plot 1, but with Plots 2 and 3; and the effect of phosphorus is ascertained by comparing Plots 6 and 7 with Plots 4 and 5, respectively.

As a general average, the plots receiving limestone have produced $1.97 an acre a year more than those without limestone, and this corresponds to more than $6 a ton for all the limestone applied; but the amounts used before 1911 were so small and the results vary so greatly with the different plots, crops, and seasons that final conclusions cannot be drawn until further data are secured, the first 2-ton applications having been completed only for 1914. However, all comparisons by rotation periods show some increase for limestone, these increases varying from $1.18 on three acres (Plot 4) during the first rotation, to $16.13 on five acres (Plot 5) as an average of the last seven years. The need of limestone for the best results and highest profits seems well established.

As an average of duplicate trials (Plots 6 and 7), phosphorus in 200 pounds of bone meal produced increases valued at $2.74 per acre per annum for the first three years and at $7.59 for the next three; and the corresponding subsequent average increases from bone meal and raw phosphate (one-half plot of each) were $7.31 for the third rotation and $6.77 for the last seven years, 1911 to 1917. In the residue system, the average yearly acre-increase for phosphorus was $6 for the first six years, and $8.02 for the next ten years; and in the manure system the corresponding average increases were $4.33 for the first six years and $5.85 for the next ten years. The annual expense per acre for phosphorus is $3.50 in bone meal at $35 a ton, or $2.70 for rock phosphate at $9 a ton.

Potassium applied at an estimated normal cost of $2.50 an acre a year, seemed to produce slight but very unprofitable increases, as an average, during the first and second rotations; but subsequently those increases have been almost entirely lost in reduced average yields, the net result to date being an average loss of $2.48 per acre per annum, or a loss of 99 cents for every dollar invested in potassium.

Thus phosphorus nearly paid its cost during the first rotation, and has subsequently paid its annual cost and about 100 percent net profit; while potassium, as an average, has produced no effect, and money spent for its application has been lost. These field results are in harmony with what might well be expected on land naturally containing in the plowed soil of an acre only about 1,100 pounds of phosphorus and 35,000 pounds of potassium.

The total value of five average crops harvested from the untreated land during the last seven years is about $111. Where limestone and phosphorus have been used together with organic manures (either crop residues or farm manure), the corresponding value is $163. Thus 200 acres of the properly treated land would produce almost as much in crops and in value as 300 acres of the untreated land.

The excessive applications on Plot 10 have usually produced rank growth of straw and stalk, with the result that oats have often lodged badly and corn has frequently suffered from drouth and eared poorly. On the whole, the extra treatment has produced but little increase over Plots 6 to 9. The largest yield of corn on Plot 10 was 118 bushels per acre in 1907.

The field investigations above described have been conducted on fifty experimental plots, laid out by Eugene Davenport a few months after he entered the service of Illinois in 1895.

But it so happens that the oldest soil experiment field in the United States is located at the University of Illinois. It was once on the farm, but is now on the campus of the institution, owing to the development and expansion of the University. This oldest field was started by George E. Morrow, for many years Professor of Agriculture. Here, on part of the field, corn has grown on the same land every year since 1879; on another part, corn and oats have grown in alternation; and on a third part, corn, oats, and clover have grown in rotation. These are known as the Morrow Plots.

On these plots, with no restoration of fertility, the acre-value of the produce, as an average of the ten-year period 1908 to 1917, was $14.15 where corn is grown every year, $17.10 where corn and oats are alternated, and $18.19 where corn, oats, and clover are rotated.

TABLE 5.—YIELDS PER ACRE ON MORROW (M) AND DAVENPORT (D) PLOTS, URBANA

Serial plot No.	Soil treatment	10-year average, 1908–17 Corn, bu.	Oats, bu.	Clover, T (bu.)[1]	Wheat, bu. 7-yr. av.	Alfalfa, tons 5-yr. av.	Average acre-value[5]
M 3	None	28.3	....	....	....	....	$14.15
M 4	None	37.6[2]	38.5[2]	....	....	....	17.10
M 5	None	40.1[3]	41.8[4]	1.78[3]	....	....	18.19
D 1	None	52.6	49.3	1.97	21.9	....	21.90
D 1	None	52.6	49.3	1.97	21.9	3.18	23.88
D 2	Residues	54.7	51.2	(1.09)	26.3	2.99	24.19
D 3	Manure	65.5	58.3	2.09	24.6	2.93	26.17
D 4	Residues, lime	59.6	52.8	(1.82)	28.3	3.25	25.98
D 5	Manure, lime	67.3	60.3	2.39	30.6	3.80	30.05
D 6	Residues, lime, phosphorus	72.0	67.2	(2.29)	42.6	4.81	35.30
D 7	Manure, lime, phosphorus	73.7	66.8	3.07	40.1	4.82	36.51
D 8	Residues, lime, phosphorus, potassium	72.2	67.5	(1.88)	41.7	4.83	34.38
D 9	Manure, lime, phosphorus, potassium	72.4	68.7	3.01	39.4	4.86	36.36

[1]Or equivalent in cowpeas or soybeans.
[2]Five-year average. [3]Three-year average. [4]Four-year average.
[5]Prices: 50 cents a bushel for corn, 40 cents for oats, $1 for wheat and soybeans, $10 for clover seed, $10 a ton for hay.

On the Davenport Plots, if we include the alfalfa yields for five years, and the wheat yields for seven years, with the ten-year averages for the corn, oats, and clover, the acre-value becomes $23.88 with no soil treatment, $35.30 with residues, limestone, and phosphorus, and $36.51 with manure, limestone, and phosphorus.

More complete details regarding these averages are given in Table 5.

As an average of the results secured during the twelve years 1903 to 1914, on the University South Farm where fine-ground raw rock phosphate is applied at the rate of 500 pounds per acre per annum on the typical brown silt loam prairie soil, the return for each ton of phosphate[1] used has been $19.39 on Series 100 and $17.24 on Series 200, with the lower prices allowed for produce, the rotation being wheat, corn, oats, and clover (or soybeans). This gives an average return of $18.31 for each ton of phosphate applied. Averages for each rotation period show the following values for the increase per ton of phosphate used:

	Lower prices	Higher prices
First rotation, 1903 to 1906	$11.80	$16.52
Second rotation, 1907 to 1910	16.19	22.66
Third rotation, 1911 to 1914	26.98	37.77

Thus, at the lower prices for produce, the rock phosphate paid back more than its cost during the first rotation, more than 1½ times its cost during the second rotation, and nearly three times its cost during the third rotation period.

One ton of fine-ground rock phosphate costs about the same as 500 pounds of steamed bone meal. Altho in less readily available form, the rock phosphate contains as much phosphorus, ton for ton, as the bone meal; and, when equal money values are applied in connection with liberal amounts of decaying organic matter, the natural rock may soon give as good results as the bone—and, by

[1]During the first four years Series 100 received only 1,500 pounds per acre of phosphate, and both series received also ½ ton per acre of limestone, the effect of which probably would be slight, as may be judged from the data secured later and reported herein.

TABLE 6.—YIELDS AND VALUES IN SOIL EXPERIMENTS, UNIVERSITY SOUTH FARM: SERIES 100
COMMON BROWN SILT LOAM PRAIRIE; EARLY WISCONSIN GLACIATION

Plot	Soil treatment applied	Corn 1903	Corn 1904	Oats 1905	Wheat 1906	Clover 1907	Corn 1908	Oats 1909	Clover 1910	Wheat[2] 1911	Corn 1912	Oats 1913	Soybeans 1914					Corn 1916	Oats 1917
		Bushels or tons per acre[1]																Bushels per acre	Bushels per acre
163	RP	45.1	54.1	57.5	39.8	(.83)	72.0	45.4	(.60)	46.9	74.9	26.8	(16.6)					37.6	78 8
166	RP	43.8	49 3	60.9	36.5	(1.00)	74.9	40.8	(1.30)	53.4	79.5	24.6	(17.5)					41.6	74.1
169	R	42.7	39.5	49.3	28.4	(.90)	65.0	39.9	(1.70)	36.7	67.9	19.1	(15 3)					29.2	59 9
170	M	41.8	38.7	52.2	26.2	2.56	69.6	40.1	2.87	35.9	76.7	22.5	1.09					37.2	67 4
173	MP	35.4	53.3	54.6	32.8	3.65	78.4	39.8	4.23	52.7	83.7	29.6	1.45					41.9	78 4
176	MP	39.3	58.1	61.9	38.8	3.74	79.5	40.0	4.23	51.0	85.6	32.1	1.52					41.5	75 1
163	RLP									49.9	87.0	28.2	(18.1)		122.78	171.88	50.9	47.2	57.3
166	RLP									53.6	81.4	26.8	(18.0)		123.02	172.22	49.6	45.7	66.6
169	R									33.8	62.7	17.0	(15.2)		87.15	122.00	25.9	33.6	61 4
170	M									32.4	74.4	22.0	1.09		89.30	125.02	31.2	34.5	63.1
173	MLP									51.3	85.7	28 0	1.37		119.05	166.66	52.4	46.6	63.6
176	MLP									51.0	85.6	30 9	1.47		120.86	169.20	53 0	44.3	66 1

TABLE 7.—YIELDS AND VALUES IN SOIL EXPERIMENTS, UNIVERSITY SOUTH FARM: SERIES 200
COMMON BROWN SILT LOAM PRAIRIE; EARLY WISCONSIN GLACIATION

Plot	Soil treatment applied	Oats 1903	Oats 1904	Wheat 1905	Clover 1903	Corn 1907							Wheat 1914						Soybeans 1917 Hay
		Bushels or tons per acre[1]																	Tons per acre
263	RP	24 7	25 7	32 1	.82	65.3	31 3	42.5	43 7	52.3	72.9	(13 7)	30.6						1.93
266	RP	23 1	24 5	29.3	.80	59.7	26.7	40.7	32.3	50.2	75.7	(12.3)	33.9						1.90
269	R	26.8	22.5	26.8	.86	57.9	31.5	39.4	25.3	35.5	61.9	(10.7)	16.1						1.68
270	M	22 0	21.5	24 0	.82	55.3	30.0	37.1	28.7	43.1	67.8	.84	17.4						1.73
273	MP	23.9	25.0	27.8	.77	62.5	29.5	43.4	43.7	38.6	69.4	1.17	37.2						1.74
276	MP	16 1	25 3	30.7	.68	58 0	27.9	44.1	38.2	48.0	68 6	1.34	42 0	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	1.85
263	RLP								49.0	50.3	78.9	(13.2)	40.4		110.31	154.44	50.0	65.5	2.01
266	RLP								45.2	47.1	78.7	(10.3)	36.0		101.33	141.86	55.8	64.0	2.08
269	R								35.3	45.3	68.4	(10.5)	20.7		81.21	113.70	53.3	60.0	2.28
270	M								33.3	45 2	73.2	1.12	20.1		83.18	116.46	55.5	66.8	1.81
273	MLP								46.2	53.7	69.0	1.27	46.2		113.35	158.58	49.6	78.4	1.90
279	MLP								39.5	50 6	69 5	1 24	49.0		114.50	160.30	53 5	75 9	1 96

[1] For legumes, figures in parentheses indicate bushels of seed; the others, tons of hay.
[2] From 1911 in Series 100, and from 1910 in Series 200, the acre-yields are based on half-plots, limestone having been applied to one half of each of the plots indicated.

supplying about four times as much phosphorus, the rock provides for greater durability.

The results just given represent averages covering the residue system and the live-stock system, both of which are represented in this crop rotation on the South Farm.

Ground limestone at the rate of 8 tons per acre was applied to the east half of these series of plots (excepting the check plots, which receive only residues or manure), beginning in 1910 on Series 200 and in 1911 on Series 100. Subsequent applications are made of 2 tons per acre each four years, beginning in 1914 on Series 200 and in 1915 on Series 100. As an average of the results from both series, the crop values were increased during the third rotation, 1911-1914, as follows:

	Residue System		Live-Stock System	
	Lower prices	Higher prices	Lower prices	Higher prices
Gain for phosphate	$26.89	$37.64	$27.07	$37.90
Gain for limestone	3.29	4.60	3.63	5.08

Detailed records of these investigations are given in Tables 6 and 7, the data being reported by half-plots after 1910-1911. (Series 300 and 400, which are also used in this rotation, are located in part upon black clay loam and a heavy phase of brown silt loam.)

Results of Experiments on Sibley Field

Table 8 gives the results obtained during twelve years from the Sibley soil experiment field located in Ford county on the typical brown silt loam prairie of the Illinois corn belt.

Previous to 1902 this land had been cropped with corn and oats for many years under a system of tenant farming, and the soil had become somewhat deficient in active organic matter. While phosphorus was the limiting element of plant food, the supply of nitrogen becoming available annually was but little in excess of the phosphorus, as is well shown by the corn yields for 1903, when the addition of phosphorus produced an increase of 8 bushels, nitrogen produced no increase, but nitrogen *and* phosphorus increased the yield by 15 bushels.

After six years of additional cropping, however, nitrogen appeared to become the most limiting element, the increase in the corn in 1907 being 9 bushels from nitrogen and only 5 bushels from phosphorus; while both together produced an increase of 33 bushels. By comparing the corn yields for the four years 1902, 1903, 1906, and 1907, it will be seen that the untreated land apparently grew less productive, whereas, on land receiving both phosphorus and nitrogen, the yield appreciably increased, so that in 1907, when the untreated rotated land produced only 34 bushels of corn per acre, a yield of 72 bushels (more than twice as much) was produced where lime, nitrogen, and phosphorus had been applied, altho the two plots produced exactly the same yield (57.3 bushels) in 1902.

Even in the unfavorable season of 1910 the yield of the highest producing plot exceeded the yield of the same plot in 1902, while the untreated land produced less than half as much as it produced in 1902. The prolonged drouth of

1911 resulted in almost a failure of the corn crop, but nevertheless the effect of soil treatment was seen. Phosphorus appeared to be the first limiting element again in 1909, 1910, and 1911; while the lodging of oats, especially on the nitrogen plots, in the exceptionally favorable season of 1912, produced very irregular results. In 1913 wheat averaged 6.6 bushels without nitrogen or phosphorus (Plots 101, 102, 105) and 22.4 bushels where both nitrogen and phosphorus were added (Plots 106, 109, 110).

TABLE 8.—CROP YIELDS IN SOIL EXPERIMENTS, SIBLEY FIELD
BROWN SILT LOAM PRAIRIE; EARLY WISCONSIN GLACIATION

Plot	Soil treatment applied	Corn 1902	Corn 1903	Oats 1904	Wheat 1905	Corn 1906	Corn 1907	Oats 1908	Wheat 1909	Corn 1910	Corn 1911	Oats 1912	Wheat 1913
		Bushels per acre											
101	None	57.3	50.4	74.4	29.5	36.7	33.9	25.9	25.3	26.6	20.7	84.4	5.5
102	Lime	60.0	54.0	74.7	31.7	39.2	38.9	24.7	28.8	34.0	22.2	85.6	6.8
103	Lime, nitro.	60.0	54.3	77.5	32.8	41.7	48.1	36.3	19.0	29.0	22.4	25.3	18.3
104	Lime, phos.	61.3	62.3	92.5	36.3	44.8	43.5	25.6	32.2	52.0	31.6	92.3	10.7
105	Lime, potas.	56.0	49.9	74.4	30.2	37.5	34.9	22.2	23.2	34.2	21.6	83.1	7.5
106	Lime, nitro., phos.	57.3	69.1	88.4	45.2	68.5	72.3	45.6	33.3	55.6	35.3	42.2	24.7
107	Lime, nitro., potas.	53.3	51.4	75.9	37.7	39.7	51.1	42.2	25.8	46.2	20.1	55.6	19.2
108	Lime, phos., potas.	58.7	60.9	80.0	39.8	41.5	39.8	27.2	28.5	43.0	31.8	79.7	11.8
109	Lime, nitro., phos., potas.	58.7	65.9	82.5	48.0	69.5	80.1	52.8	35.0	58.0	35.7	57.2	24.5
110	Nitro., phos., potas.	60.0	60.1	85.0	48.5	63.3	72.3	44.1	30.8	64.4	31.5	54.1	18.0
	Increase: Bushels per Acre												
	For nitrogen	.0	.3	2.8	1.1	2.5	9.2	11.6	-9.8	-5.0	.2	-60.3	11.5
	For phosphorus	1.3	8.3	17.8	4.6	5.6	4.6	.9	3.4	18.0	9.4	6.7	3.9
	For potassium	-4.0	-4.1	-.3	-1.5	-1.7	-4.0	-2.5	-5.6	.2	-.6	-2.5	.7
	For nitro., phos. over phos.	-4.0	6.8	-4.1	8.9	23.7	28.8	20.0	1.1	3.6	3.7	-50.1	14.0
	For phos., nitro., over nitro.	-2.7	14.8	10.9	12.4	24.8	24.2	9.3	14.3	26.6	12.9	16.9	6.4
	For potas., nitro., phos. over nitro., phos.	1.4	-3.2	-5.9	2.8	1.0	7.8	7.2	1.7	2.4	.4	15.0	-.2

Value of Crops per Acre in Twelve Years

Plot	Soil treatment applied	Total value of twelve crops: Lower prices	Total value of twelve crops: Higher prices
101	None	$246.98	$345.78
102	Lime	266.45	373.02
103	Lime, nitrogen	253.49	354.88
104	Lime, phosphorus	311.11	435.56
105	Lime, potassium	239.03	334.64
106	Lime, nitrogen, phosphorus	352.73	493.82
107	Lime, nitrogen, potassium	283.08	396.32
108	Lime, phosphorus, potassium	292.71	409.80
109	Lime, nitrogen, phosphorus, potassium	368.45	515.82
110	Nitrogen, phosphorus, potassium	346.38	484.94

Value of Increase per Acre in Twelve years

	Lower prices	Higher prices
For nitrogen	-$12.96	-$18.14
For phosphorus	44.66	62.54
For *nitrogen* and phosphorus over phosphorus	41.62	58.26
For *phosphorus* and nitrogen over nitrogen	99.24	138.94
For *potassium*, nitrogen, and phosphorus over nitrogen and phosphorus	15.72	22.00

In the lower part of Table 8 is shown the total value of the twelve crops from each of the ten different plots, the amounts varying at the lower prices (50 cents a bushel for corn, 40 cents for oats, and $1 for wheat) from $239.03 to $368.45 per acre. Phosphorus without nitrogen has produced $44.66 in addition to the increase by lime, but with nitrogen it has produced $99.24 above the crop values where only lime and nitrogen have been used. The results show that in 26 cases out of 48 the addition of potassium has decreased the crop yields. Even when applied in addition to phosphorus, and with no effort to liberate potassium from the soil by adding organic matter, potassium has produced no increase in crop values as an average of the results from Plots 108 and 109.

By comparing Plots 101 and 102, and also 109 and 110, it is seen that lime has produced an average increase of $20.77, or $1.73 an acre a year. The increase on these plots is nearly the same as on the field at Urbana, and it suggests that the time is here when limestone must be applied to some of these brown silt loam soils.

While nitrogen, on the whole, has produced an appreciable increase, especially on those plots to which phosphorus has also been added, it has cost, in commercial form, so much above the value of the increase produced that the only conclusion to be drawn, if we are to utilize the fact to advantage, is that the nitrogen must be secured from the air.

RESULTS OF EXPERIMENTS ON BLOOMINGTON FIELD

Space is taken to insert Tables 9 and 10, giving all results thus far obtained from the Bloomington soil experiment field, which is also located on the brown silt loam prairie soil of the Illinois corn belt.

PLATE 6.—CORN IN 1912 ON BLOOMINGTON FIELD
ON LEFT, RESIDUES, LIME, AND POTASSIUM: YIELD, 58.9 BUSHELS
ON RIGHT, RESIDUES, LIME, AND PHOSPHORUS: YIELD, 86.1 BUSHELS

TABLE 9.—CROP YIELDS IN SOIL EXPERIMENTS, BLOOMINGTON FIELD
BROWN SILT LOAM PRAIRIE; EARLY WISCONSIN GLACIATION

Increase: Bushels or Tons per Acre

For residues	-1.9	-.8	9.0	1.7	-.12	1.2	1.6	-4.2		3.1	14.6	7.5	-9.8		5.3	10.4
For phosphorus	4.7	12.7	11.9	10.4	1.07	19.0	12.2	10.2	3.12	35.1	26.6	14.1	4.4		23.0	24.8
For potassium	.7	-3.9	1.7	4.4	-.07	1.0	.9	-8.3	.15	-.8	9.9	2.1	-4.8		.9	11.0
For residues, phosphorus over phos.	2.2	4.6	12.6	11.7	-1.65	-3.2	-1.7	8.7		2.6	11.6	6.3	17.3		1.4	3.6
For phosphorus, residues over residues	8.8	18.1	15.5	20.4	-.46	14.6	8.9	23.1	(.84)	34.6	23.6	12.9	31.5		19.1	18.0
For potas., res., phos., over res., phos.	8.8	3.3	5.2	1.0	.00	9.5	12.3	-8.3	(-1.25)	.2	-2.7	-1.4	-7.9		3.6	.7

[1]Commercial nitrogen was used from 1902 to 1905, after which crop residues were substituted.
[2]For clover the figures indicate tons per acre, except where in parentheses, in which case they indicate bushels of seed.
[3]Clover smothered by previous wheat crop.
[4]The soybeans in 1915 were entirely destroyed by hail. Nothing was harvested and the residue was plowed under on all plots.

The general results of the first twelve years' work tell much the same story as those from the Sibley field. The rotations differed after 1905 by the use of clover and the discontinuing of the use of commercial nitrogen,—in consequence of which phosphorus without commercial nitrogen, on the Bloomington field, produced an even larger increase ($140.89) than was produced by phosphorus and nitrogen over nitrogen on the Sibley field ($99.24).

It should be stated that a draw runs near Plot 110 on the Bloomington field, that the crops on that plot are sometimes damaged by overflow or imperfect drainage, and that Plot 101 occupies the lowest ground on the opposite side of the field. In part because of these irregularities and in part because only one small application has been made, no conclusions can be drawn in regard to lime. Otherwise all results reported in Table 9 are considered reliable. They not only furnish much information in themselves, but they also offer instructive comparison with the Sibley field.

Wherever nitrogen has been provided, either by direct application or by the use of legume crops, the addition of the element phosphorus has produced very marked increases, the average yearly increase for the Bloomington field being worth $9.90 an acre, at the lower prices, as a sixteen-year average. This is $6.40 above the cost of the phosphorus in 200 pounds of steamed bone meal, the form in which it is applied on the Sibley and the Bloomington fields. On the other hand, the use of phosphorus without nitrogen will not maintain the fertility of the soil (see Plots 104 and 106, Sibley field). As the only practical and profitable method of supplying nitrogen, a liberal use of clover or other legume is suggested, the legume to be plowed under either directly or as manure, preferably in connection with the phosphorus applied, especially if raw rock phosphate is used.

From the soil of the best treated plots on the Bloomington field, 204 pounds per acre of phosphorus, as an average, has been removed in the fifteen crops.

TABLE 10.—VALUE OF CROPS PER ACRE IN SIXTEEN YEARS, BLOOMINGTON FIELD

Plot	Soil treatment applied	Total value of fifteen crops: Lower prices[1]	Total value of fifteen crops: Higher prices[2]
101	None	$299.55	$419.37
102	Lime	292.20	409.08
103	Lime, residues	312.80	437.92
104	Lime, phosphorus	470.25	658.35
105	Lime, potassium	303.99	425.59
106	Lime, residues, phosphorus	471.19	659.67
107	Lime, residues, potassium	307.20	430.08
108	Lime, phosphorus, potassium	485.01	679.01
109	Lime, residues, phosphorus, potassium	474.34	664.08
110	Residues, phosphorus, potassium	434.95	608.93
	Value of Increase per Acre in Fifteen Crops		
	For residues	$20.60	$28.84
	For phosphorus	178.05	249.27
	For *residues* and phosphorus over phosphorus	.94	1.32
	For *phosphorus* and residues over residues	158.39	221.75
	For *potassium*, residues, and phosphorus over residues and phosphorus	3.15	4.41

[1]Wheat at $1 a bushel, corn at 50 cents, oats at 40 cents, hay at $10 a ton.
[2]Wheat at $1.40 a bushel, corn at 70 cents, oats at 56 cents, and hay at $14 a ton.

This is equal to 17 percent of the total phosphorus contained in the surface soil of an acre of the untreated land. In other words, if such crops could be grown for ninety years, they would require as much phosphorus as now constitutes the total supply in the ordinary plowed soil. The results plainly show, however, that without the addition of phosphorus such crops cannot be grown year after year. Where no phosphorus has been applied, the crops have removed only 132 pounds of phosphorus during the same period, which is equivalent to only 11 percent of the total amount (1,200 pounds) present in the surface soil at the beginning of the experiment in 1902. The total phosphorus applied from 1902 to 1917, as an average of all plots where it has been used, has amounted to 400 pounds per acre and has cost $56.[1] This has paid back $171.15, or 300 percent on the investment; whereas potassium, used in the same number of tests has paid back only $6.02 per acre in the sixteen years, or about 15 percent of its normal cost, leaving a net loss of 85 cents from each dollar invested in potassium. Are not these results to be expected from the composition of such soil and the requirement of crops? (See Table 2; also Table A in the Appendix.)

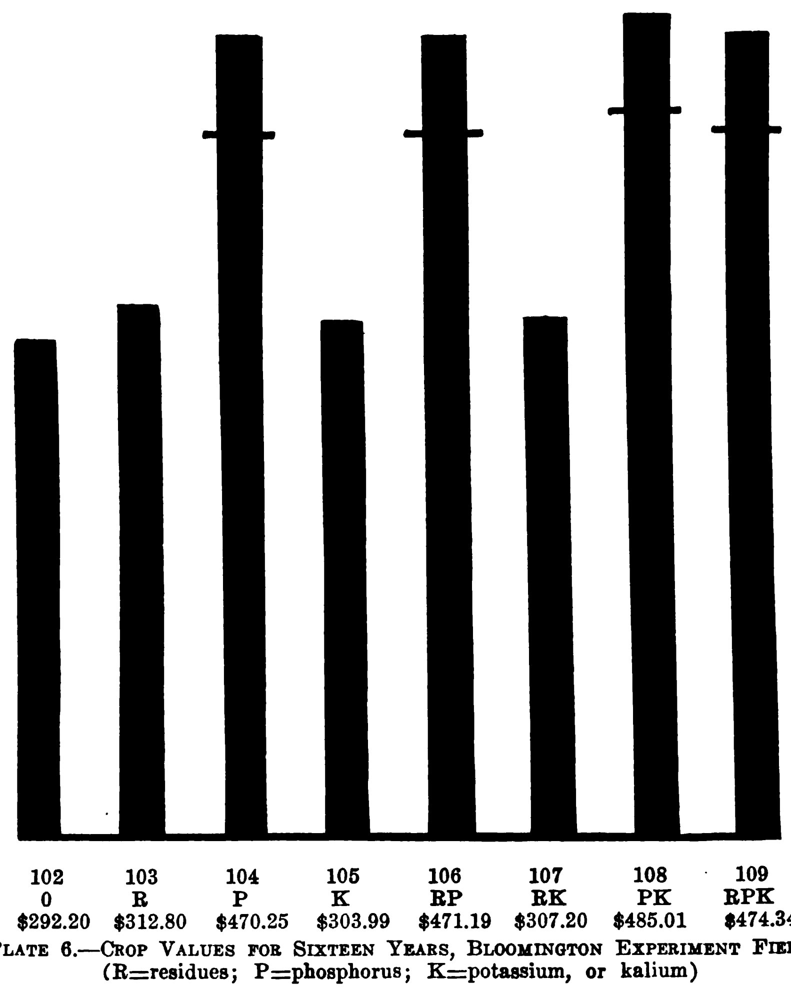


PLATE 6.—CROP VALUES FOR SIXTEEN YEARS, BLOOMINGTON EXPERIMENT FIELD
(R=residues; P=phosphorus; K=potassium, or kalium)

[1]This is based on $35 a ton for steamed bone meal; in earlier years the price was about $25.

Nitrogen was applied to the residue plots of this field, in commercial form only, from 1902 to 1905; but clover was grown in 1906 and 1910, and a cover crop of cowpeas after the clover in 1906. The cowpeas were plowed under on all plots, and the 1910 clover (except the seed) was plowed under on the five residue plots. Straw and corn stalks have also been returned to these plots, beginning with 1908. The effect of returning these residues to the soil has been appreciable since 1908 (an average increase on Plot 106 of 2.0 bushels of wheat, 7.2 bushels of corn, and 13.0 bushels of oats) and probably will be more marked on subsequent crops. Indeed, the large crops of corn, oats, and wheat grown on Plots 104 and 108 during the sixteen years have drawn their nitrogen very largely from the natural supply in the organic matter of the soil. The roots and stubble of clover contain no more nitrogen than the entire plant takes from the soil alone, but they decay rapidly in contact with the soil and probably hasten the decomposition of the soil humus and the consequent liberation of the soil nitrogen. But of course there is a limit to the reserve stock of humus and nitrogen remaining in the soil, and the future years will undoubtedly witness a gradually increasing difference between Plots 104 and 106, and between Plots 108 and 109, in the yields of grain crops.

Plate 7 shows graphically the relative values of the fifteen crops for the years 1902 to 1917, for the eight comparable plots, Nos. 102 to 109. The

TABLE 11.—FERTILITY IN THE SOILS OF CHAMPAIGN COUNTY, ILLINOIS
Average pounds per acre in 4 million pounds of subsurface soil (about 6⅔ to 20 inches)

Soil type No.	Soil type	Total organic carbon	Total nitrogen	Total phosphorus	Total potassium	Total magnesium	Total calcium	Limestone present	Soil acidity present
	Upland Prairie Soils (900, 1100)								
926, 1126	Brown silt loam ...	72 330	6 390	1 690	74 080	25.050	20 510		50
920, 1120	Black clay loam....	65 500	6 140	2 620	69 600	30 240	34 230	Often	
928, 1128	Brown-gray silt loam on tight clay	27 080	3 240	1 440	64 980	14 380	9 060		3 040
1121	Drab clay loam....	54 440	5 420	2 180	72 580	28 660	30 740	Often	Often
1160	Brown sandy loam.	44 240	3 800	1 560	54 200	13 760	12 400		400
	Upland Timber Soils (900, 1100)								
934, 1134	Yellow-gray silt loam............	20 440	2 410	1 410	72 410	23 950	14 410		1 840
935, 1135	Yellow silt loam...	12 560	1 120	1 720	76 880	15 600	12 040		160
1164	Yellow-gray sandy loam............	16 080	1 160	1 240	60 080	8 680	10 440		40
	Terrace Soils (1500)								
1536	Yellow-gray silt loam over sand or gravel.........	16 080	2 180	1 940	74 620	20 060	11 580		3 560
1527	Brown silt loam over sand or gravel	63 040	5 920	2 080	72 960	19 600	14 080		40
1560	Brown sandy loam.	48 720	4 400	1 600	66 040	12 880	15 560		40
	Swamp and Bottom-Land Soils (1400)								
1454	Mixed loam.......	76 200	7 180	2 260	77 180	23 680	26 540		Often
1401	Deap peat[1]	650 500	53 160	2 100	13 480	11 800	66 600	15 040	
1402	Medium peat on clay[1]............	181 400	14 260	780	34 880	16 200	21 320		60

[1]Amounts reported are for 2 million pounds of deep peat and medium peat.

cost of the phosphorus is indicated by that part of the diagram above the short crossbars. It should be kept in mind that no value is assigned to clover plowed under except as it reappears in the increase of subsequent crops. Plots 106 and 109 are heavily handicapped because of the clover failure on those plots in 1906 and the poor yield of clover seed in 1910, whereas Plots 104 and 108 produced a fair crop in 1906 and a very large crop in 1910. Plot 106, which receives the most practical treatment for permanent agriculture (RLP), has produced a total value in sixteen years which is only 94 cents above that from Plot 104 (LP). (See also table on last page of cover.)

THE SUBSURFACE AND SUBSOIL

In Tables 11 and 12 are recorded the amounts of plant food in the subsurface and the subsoil of the different types of soil in Champaign county, but it should be remembered that these supplies are of little value unless the top soil is kept rich. Probably the most important information contained in these tables is that the most common upland soils are usually acid in the surface and subsurface and sometimes contain no limestone in the subsoil. These tables also show great stores of potassium and only limited amounts of phosphorus, in agreement with the data for the surface stratum (Table 2).

TABLE 12.—FERTILITY IN THE SOILS OF CHAMPAIGN COUNTY, ILLINOIS
Average pounds per acre in 6 million pounds of subsoil (about 20 to 40 inches)

Soil type No.	Soil type	Total organic carbon	Total nitrogen	Total phosphorus	Total potassium	Total magnesium	Total calcium	Limestone present	Soil acidity present
	Upland Prairie Soils (900, 1100)								
926, 1126	Brown silt loam...	33 510	3 920	2 250	118 690	56 850	49 010	Often	Often
920, 1120	Black clay loam...	29 110	3 330	3 230	109 130	62 330	76 600	Often	
928, 1128	Brown-gray silt loam on tight clay	21 240	2 730	2 130	102 840	33 810	17 760		1 590
1121	Drab clay loam....	37 470	3 780	2 610	111 030	62 580	80 370	Often	Often
1160	Brown sandy loam.	20 040	1 800	1 740	81 540	21 180	18 480		1 680
	Upland Timber Soils (900, 1100)								
934, 1134	Yellow-gray silt loam...........	17 860	2 700	2 340	113 660	51 660	37 260	Often	Often
935, 1135	Yellow silt loam...	14 040	1 440	2 940	108 060	28 140	21 180		720
1164	Yellow-gray sandy loam...........	11 400	1 020	1 800	82 560	14 220	15 300		300
	Terrace Soils (1500)								
1536	Yellow-gray silt loam over sand or gravel..........	15 810	2 610	2 730	134 340	61 830	34 950	Often	Often
1527	Brown silt loam over sand or gravel	38 100	3 840	2 460	99 840	33 420	20 400		600
1560	Brown sandy loam	21 180	2 100	1 800	105 240	23 940	19 260		60
	Swamp and Bottom-Land Soils (1400)								
1454	Mixed loam.......	39 690	3 990	2 010	111 990	31 110	32 760		60
1401	Deep peat[1]........	248 160	17 880	1 290	50 160	21 150	32 730	28 080	
1402	Medium peat on clay............	218 760	16 140	2 640	128 520	101 100	135 420	437 280	

[1] Amounts reported are for 3 million pounds of deap peat.

INDIVIDUAL SOIL TYPES

(a) UPLAND PRAIRIE SOILS

The upland prairie soils of Champaign county occupy 911 square miles, or 92.2 percent of the area of the county. They are black or brown in color, owing to their large content of organic matter.

The accumulation of organic matter in the prairie soils is due to the growth of prairie grasses that once covered them, whose network of roots was protected from complete decay by the imperfect aeration resulting from the covering of fine soil material and the moisture it contained. On the native prairies, the tops of these grasses were usually burned or decayed almost completely, so that they added very little organic matter to the soil. From a sample of virgin sod of "blue stem," one of the most common prairie grasses, it has been determined that an acre of this soil to a depth of 7 inches contained 13.5 tons of roots. Many of these roots died each year and by partial decay formed the humus of these dark prairie soils.

Brown Silt Loam (1126, *or* 926 *on moraines*)

Brown silt loam is the most important as well as the most extensive soil type in Champaign county. It covers an area of 720 square miles (460,800 acres), or 72.9 percent of the county. This type occupies the slightly undulating to rolling areas of the prairie land, including both morainal and intermorainal areas. Many of these areas are well surface-drained, tho many need artificial drainage. The morainal areas are sometimes so rolling that considerable care is required to prevent erosion. Altho brown silt loam is normally a prairie soil, yet in some limited areas forests have recently invaded it, but not changed it materially. These forests consist quite largely of black walnut, wild cherry, hackberry, ash, hard maple, and elm. A black-walnut soil is recognized generally by farmers as being one of the best timber soils, but this is because of the fact that it still contains a large amount of organic matter, characteristic of prairie soils. After the growth of several generations of trees, the organic matter would become so reduced that the soil would then be classed as a timber type.

The surface soil, 0 to 6⅔ inches, is a brown silt loam, varying on the one hand to black as it grades into black clay loam (1120), and on the other hand to grayish brown or yellowish brown as it grades into the timber type, yellow-gray silt loam (934 or 1134). In physical composition it varies to some extent, but it is normally a silt loam, containing from 65 to 80 percent of silt, together with some sand, and from 10 to 15 percent of clay. The amount of clay increases as the type approaches black clay loam (1120), and becomes greatest in the level, poorly drained areas. The amount of sand varies from 15 to 25 percent.

The organic-matter content varies from about 4 to 6 percent, with an average of 4.9 percent, or 49 tons per acre. The amount is less in the more rolling areas than in the low and poorly drained parts, owing not only to the fact that less vegetation grows on the drier, rolling areas, but also to the fact that

when incorporated with the soil much of it is removed by erosion and undergoes greater decomposition, because of better aeration and less moisture. Where the type passes into the yellow-gray silt loam (934 or 1134), the organic-matter content becomes less, while it is greater in the low, swampy tracts, where the grasses grew more luxuriantly, and where the large moisture content furnished conditions more favorable for the preservation of organic matter of the grass roots.

The natural subsurface is represented by a stratum varying from 6 to 16 inches in thickness. On the moraines, the stratum is thin and light in color. It varies in physical composition in the same way as the surface soil, but it usually contains a slightly larger amount of clay, especially as it approaches the black clay loam (1120). In both color and depth the stratum varies with the topography, being lighter in color as well as shallower on the more rolling areas and where the type grades into yellow-gray and yellow silt loam (1134 or 1135). The amount of organic matter varies with depth, but the average for this stratum (which is twice the thickness of the surface soil as it is sampled) is 3.2 percent, or 64 tons per acre.

The natural subsoil begins at a depth of 12 to 23 inches beneath the surface, and extends to an indefinite depth, but is sampled from 20 to 40 inches. It varies with the topography both in color and texture; with depth it becomes slightly coarser. It consists of a yellow or drabbish mottled yellow, clayey silt or silty clay, plastic when wet. Where the drainage has been good, it is of a

PLATE 8.—A VERY WASTEFUL WAY OF DISPOSING OF CORN STALKS. NITROGEN IS LOST, AND AT PRESENT PRICES (1918), THIS MEANS A LOSS OF MORE THAN $4 FOR EACH TON OF STALKS BURNED. THE ORGANIC MATTER, WHICH HAS A HIGH VALUE IN KEEPING THE SOIL IN GOOD PHYSICAL CONDITION, IS ALSO LOST

bright to pale yellow color. With poor drainage, it approaches a drab or olive color with pale yellow mottlings or a yellow color with mottlings of drab.

Each of the three strata is pervious to water, so that drainage takes place with little difficulty.

On the more rolling moraines the glacial drift is sometimes encountered less than 30 inches from the surface, owing to the removal of part of the fine loessial material by erosion. Where the drift is quite compact, as is occasionally the case, the subsoil is somewhat inferior, owing to its less pervious character. This condition, however, does not occur very often nor over very large areas, since most of the drift is pervious and some of it is quite gravelly. Occasionally glacial till forms the surface soil, and where this occurs the soil may be quite gravelly. Gravel may sometimes be found in the surface soil in draws where the small pebbles have been washed down during heavy rains from the adjoining higher land of exposed glacial drift.

In the eastern part of the county in Township 19 North, Ranges 10 and 11 East of 3d P. M., and Range 14 West of 2d P. M., this type contains more fine and medium sand than usual, and even some very small areas of sandy loam, too small to be shown on the map as a separate type. These areas are not objectionable; in fact the small increase in sand is even desirable as it improves the working qualities of the soil.

When the virgin brown silt loam was first cropped, the soil was in fine tilth, worked easily, and large crops could be grown with much less work than now. Continuous cropping, however, to corn or corn and oats with the burning of corn stalks, stubble, grass, and in many cases even straw, has destroyed the tilth in a great measure and now the soil is more difficult to work, washes badly, runs together, and bakes more. Unless the moisture conditions are very favorable, the ground plows up cloddy, and unless well-distributed rains follow, a good seed bed is difficult to produce. The clods may remain all season. Much plant food is locked up in them and thus made unavailable, so that the best results cannot be obtained. This condition of poor tilth may become serious if the present methods of management continue; it is already one of the factors that limit crop yields. The remedy is to increase the organic-matter content by plowing under every available form of vegetable material, such as farm manure, corn stalks, straw, clover, stubble, and even weeds.

The deficiency of organic matter in the soils is shown by the way the fall-plowed land runs together during the winter. Much more work is required to produce a seed bed than was formerly the case. The result is that corn is frequently planted in poorly prepared seed beds and as a consequence it "fires" badly. Fall-plowed land should be disked early and deep for the purpose of conserving moisture, increasing temperature, and making plant food available.

The addition of fresh organic matter is not only of great value in improving the physical condition of this type of soil, but it is of even greater importance because of its nitrogen content and because of its power, as it decays, to liberate potassium from the inexhaustible supply in the minerals of the soil and phosphorus from the phosphate contained in or applied to the soil.

For permanent, profitable systems of farming on brown silt loam, phosphorus should be applied liberally, and sufficient organic matter should be pro-

PLATE 9.—A GOOD SEED BED FOR OATS PRODUCED BY THE DISK AND SPIKE-TOOTH HARROW WHERE THE STALKS ARE LEFT ON THE SURFACE

PLATE 10.—A GOOD SEED BED FOR CORN WHERE THE STALKS HAVE BEEN TURNED UNDER

vided to furnish the necessary amount of nitrogen. On the ordinary type, limestone is already becoming deficient. An application of two tons of limestone and one-half ton of fine-ground rock phosphate per acre every four years, with the return to the soil of all manure made from a rotation of corn, corn, oats, and clover, will maintain the fertility of this type, altho heavier applications of phosphate may well be made during the first two or three rotations, and the first application of limestone may well be four tons per acre. If grain farming is practiced, the rotation may be wheat, corn, oats, and clover, with an extra seeding of clover (preferably sweet clover) as a cover crop in the wheat, to be plowed under late in the fall or in the following spring for corn; and most

PLATE 11.—A DEFICIENCY OF ORGANIC MATTER WILL CAUSE FALL-PLOWED LAND TO RUN TOGETHER AND CRACK

of the crop residues, including the clover chaff from the seed crops, should also be plowed under. In either system, alfalfa may be grown on a fifth field and moved every five years, the hay being fed or sold. In live-stock farming, the regular rotation may be extended to five or six years by seeding both timothy and clover with the oats, and pasturing one or two years. Alsike may well replace red clover at times, in order to avoid clover sickness. (For results secured in field experiments on brown silt loam, see the preceding pages.)

Black Clay Loam (1120, *or* 920 *on Moraines*)

Black clay loam represents the flat prairie. It is sometimes called "gumbo" because of its sticky character. Its formation in the flat, poorly drained areas is due to the accumulation of organic matter and to the washing in of clay and fine silt from the slightly higher adjoining lands. This type occupies 176.47 square miles (112,940 acres), or 17.86 percent of the entire area of the county. It is so flat that dredge ditches and tile drainage are often required to solve one of the most difficult problems in its management.

The surface soil, 0 to 6⅔ inches, is a black, plastic, granular clay loam, varying locally to a black, clayey silt loam. It contains, on an average, 6.3 percent of organic matter, or 63 tons per acre, but it varies considerably from this average. In physical composition, this stratum varies somewhat as it grades into other types. As it passes toward brown silt loam, which nearly always surrounds it, it becomes more silty. In some of the former sloughs, the water or floating ice has carried considerable small gravel which has been deposited in sufficient abundance over small areas to form a gravelly black clay loam.

The subsurface stratum has a thickness of 10 to 16 inches and varies from a black to a brownish gray clay loam, usually somewhat heavier than the surface soil. The average amount of organic matter is 2.8 percent, or 56 tons per

acre. The lower part of this stratum frequently is a drab or yellowish drab silty clay. The stratum is quite pervious to water, owing to the jointing or checking from shrinkage in times of drouth and to the action of crayfish and other animals.

The subsoil to a depth of 40 inches varies from a drab to a yellowish drab silty clay. As a rule, the iron is not highly oxidized, because of poor drainage and lack of aeration. Concretions of carbonate of lime are frequently found. The perviousness of the subsoil is about the same as that of the subsurface and is due to the same causes. When thrown out on the surface where wetting and drying may take place, the subsoil soon breaks into small cubical masses. Gravel is frequently present.

Black clay loam presents many variations. In Champaign county as elsewhere, the boundary lines between it and the brown silt loam are not always distinct. In some areas topography is a great help in locating the boundary, but in other places there may be an intermediate zone of greater or less width. The washing in of silty material from the surrounding higher lands, especially near the edges of the areas, modifies the character of the soil, giving the surface a silty character. This change is taking place more rapidly now, with the annual cultivation of the soil, than formerly, when washing was largely prevented by prairie grasses. Part of the areas mapped as black clay loam grade toward drab clay loam, the black soil not being very deep, and passing into a drab or yellowish drab color at a depth of 10 to 14 inches.

Occasional small patches of alkali soil occur in the black clay loam areas. These spots are indicated by the fact that oats lodge badly and corn makes a poor growth, usually turning greenish yellow, yellow, or brown. If the amount of alkali is large, the corn may not grow over two or three feet high and presents a bushy appearance. If it reaches almost normal height, it does not produce much grain. This condition is due to an excess of injurious carbonates in the soil. The remedy is to drain the land thoroly and to turn under horse manure, coarse stable manure, straw, corn cobs, or green manure. The straw of lodged oats may well be plowed under for corn. Drainage is the first requirement in the management of this type. Altho it usually has but little slope, yet because of its perviousness it is easily tile-drained. Keeping the soil in good physical condition is very essential, and thoro drainage helps to do this to a great extent. As the organic matter is destroyed by cultivation and nitrification, and as the limestone is removed by cropping and leaching, the soil becomes poorer in physical condition, and as a consequence it becomes more difficult to work. Both organic matter and limestone tend to develop granulation. The former should be maintained by turning under manure or such crop residues as corn stalks and straw, and by the use of clover and pasture in rotations. Ground limestone should be applied when needed to keep the soil sweet. It should be remembered that the difficulty of working clay soils is in proportion to their deficiency in organic matter.

While black clay loam is one of the best soils in the state, yet the clay and humus which it contains give it the property of shrinkage and expansion to such a degree as to be somewhat objectionable at times, especially during drouth. When the soil is wet, these constituents expand, and when the moisture evap-

orates or is used by crops, they shrink. This results in the formation of cracks, sometimes as much as two or more inches in width at the surface and extending with lessening width to two or three feet in depth. During the drouth of 1914, the cracks were so large and deep that in many cases a one-inch auger could be forced into them, without turning, to a depth of more than two feet. These cracks allow the soil strata to dry out rapidly, and as a result the crop is injured thru lack of moisture. They may do considerable damage by "blocking out" hills of corn and severing the roots. While cracking may not be prevented entirely, good tilth with a soil mulch will do much toward that end. Both for aeration and for producing a mulch for conserving moisture, cultivation is more essential on this type than on the brown silt loam. It must be remembered, however, that cultivation should be as shallow as possible, in order to prevent injury to the roots of the corn. (See Bulletin 181, Soil Moisture and Tillage for Corn.)

At Urbana, on the South Farm of the University of Illinois, a series of plots devoted chiefly to variety tests and other crop-production experiments extends across an area of black clay loam. Where rock phosphate has been applied at the rate of 500 pounds an acre a year in connection with crop residues, in a four-year rotation of wheat, corn, oats, and clover (or soybeans), the value of the increase produced per ton of phosphate has been, in three successive rotation periods, \$3.04, \$6.71, and \$9.26, respectively, at the lower prices for produce, or \$4.26, \$9.40, and \$12.96, respectively, at the higher prices. In the live-stock system, the phosphorus naturally supplied in the manure, supplemented by that liberated from this fertile soil, has thus far been nearly sufficient to meet the crop requirements; the increase in crop values per ton of phosphate applied having been, as an average for the twelve years, only \$3.26 at the lower prices, or \$4.52 at the higher prices. These returns are less than half the cost of the phosphorus applied, and in some seasons no benefit appears.

This type is rich in magnesium and calcium, and in the Wisconsin glaciation it sometimes contains plenty of carbonates. With continued cropping and leaching, applications of limestone will ultimately be needed.

Drab Clay Loam (1121)

The drab clay loam occupies 9.58 square miles (6,131 acres), or .97 percent of the area of the county. The topography is flat, or about the same as that of the black clay loam (1120).

The surface soil, 0 to 6⅔ inches, is a clay loam, usually a little heavier than black clay loam (1120), but not so dark and in some cases it may have a slightly grayish color. The organic-matter content averages 4.9 percent, or 49 tons per acre. Typically it should contain about 4 percent, but it grades into black clay loam, and this increases the amount. The change to drab clay loam is usually noticeable immediately beneath the surface soil.

The subsurface soil is a stratum of indefinite thickness, owing to the fact that it is very difficult to determine where the natural subsurface ends and the subsoil begins, there being no distinct change in color or texture. In color the subsurface varies from a brown to a drab or olive; in texture it is a plastic, per-

vious clay loam. The organic-matter content averages 46 tons per acre, which is less than for either black clay loam or brown silt loam.

The subsoil is a dull yellow or olive-colored silty clay. Limestone concretions sometimes occur in this stratum.

In general this type should receive the same treatment as black clay loam, except that greater effort should be made to maintain the content of organic matter, since this type is lower in that constituent.

Brown-Gray Loam on Tight Clay (928, 1128)

Brown-gray silt loam on tight clay occurs in small areas thruout the county, many of which are not large enough to be shown on the map. The total area is 4.11 square miles (2,630 acres) or .42 percent of the total area of the county. The larger areas are found in the south-central part of the county, near the Embarrass river. This type occurs as a shelf between the overflow land and the upland. In some areas it is underlain by a stratum of gravel at a depth of five to seven feet. This gravel stratum is not very thick. The topography is flat and natural drainage is poor.

The surface soil, 0 to 6⅔ inches, is a grayish brown to gray silt loam. It varies in color with the content of organic matter. Near brown silt loam it is of a darker color, while in some spots it is gray. This stratum contains about 3.3 percent of organic matter, or 33 tons per acre. It contains some fine sand and coarse silt, which give it a peculiar mealy or floury feel, but excellent texture. Some medium-sized gravel are found that have been brought up by crayfish.

The subsurface soil, 6⅔ to 18 inches, is a gray to a yellowish gray silt to silt loam, which contains 1.2 percent of organic matter. This stratum is very slowly pervious to water.

The subsoil is a gray to yellowish gray silt to clayey silt, a little less pervious, perhaps, than the subsurface. It begins at a depth of about 18 inches. When dry, this stratum becomes very hard and difficult to remove, except with a pick. The content of organic matter is .6 percent.

Naturally this soil is one of the poorest in the county, being wet and usually difficult to drain, comparatively low in organic matter and fertility, and decidedly acid. The first requirement is drainage, either by means of tile or surface ditches. The lines of tile must be placed closer together than in any other type in the county. The distance should not be over four rods.

This soil is the most acid of all the types in the county, and it is also quite deficient in phosphorus and nitrogen. It should have an initial application of about four tons of limestone and one ton of rock phosphate per acre. Afterward about one-half these amounts for each rotation will maintain the supply, altho the heavier applications of phosphate may well be continued for several rotations. The organic matter and nitrogen should be increased in every practical way, such as by turning under crop residues, manure, and clover. Deep-rooting crops are especially beneficial to this soil, since they aid drainage and deeper aeration. For this reason, mammoth and sweet clovers are recommended for this type. The soil runs together badly, and the application of limestone and the increase of organic matter will aid in preventing this. When

fall-plowed, the soil becomes packed by spring almost as hard as it was before plowing. About the only advantages of fall plowing are that it turns under the organic matter so that it is partly decomposed by the time the crop is put in, and that it permits earlier working in the spring.

Brown Sandy Loam (1160)

Brown sandy loam occupies only 557 acres, or .09 percent of the area of the county. It occurs in small areas in the east-central part of the county representing old beach or shore lines of a temporary lake. The sand was blown up into low dunes that now constitute the sandy loam.

The surface soil, 0 to $6\frac{2}{3}$ inches, is a brown sandy loam, varying in sand content as well as in color. The tops of the low dunes or ridges are generally more sandy than the sides, owing to the fact that the fine material has been washed away. For the same reason the soil of these ridges is lighter in color. This stratum contains about 2.5 percent, or 25 tons of organic matter per acre.

The subsurface soil, $6\frac{2}{3}$ to 15 inches, is a light brown sandy loam with 1.9 percent of organic matter, or 38 tons per acre.

The subsoil varies from a yellow clayey silt to a yellow sand.

This type is a very good soil, but it is low in nitrogen and distinctly acid. For its marked and profitable improvement liberal use should be made of limestone and legume crops. While the soil is not rich in phosphorus on the percentage basis, it is so porous that it affords a deep feeding range for plant roots, and hence additional supplies of phosphorus are not likely to be profitable until the present supply is reduced.

PLATE 12.—EFFECT OF ROCK PHOSPHATE AND LIMESTONE ON THE GROWTH OF CLOVER ON BROWN-GRAY SILT LOAM ON TIGHT CLAY. THE CHECK STRIP ON THE LEFT IS COVERED WITH GRASS AND WEEDS, THE CLOVER HAVING FAILED ALMOST ENTIRELY

(b) UPLAND TIMBER SOILS

The upland timber soils usually occur along streams, altho two exceptions are found in Champaign county where forests exist remote from streams. Timber soils are characterized by a yellow, yellowish gray, or gray color, due to their low organic-matter content resulting from the long-continued growth of forest trees. As the forests invaded the prairies, two effects were produced: (1) the shading by the trees prevented the growth of prairie grasses, the roots of which are mainly responsible for the large amount of organic matter in prairie soils; (2) the trees themselves added very little organic matter to the soil, for the leaves and fallen branches either decayed completely or were burned by forest fires. As a result the organic-matter content has been reduced to a low percentage.

Yellow-Gray Silt Loam (934, 1134)

Yellow-gray silt loam occurs in the outer timber belts along streams and in the less rolling of the timbered morainal areas. The type covers 45.16 square miles (28,902 acres), or 4.57 percent of the entire area of Champaign county. In topography it is sufficiently rolling for good surface drainage, without much tendency to wash if proper care is taken.

The surface soil, 0 to 6⅔ inches, is a yellow, yellowish gray, gray or brownish gray silt loam, having a floury feel. The more nearly level areas are gray in color, while the more rolling phase of the type has a yellow or brownish yellow color. As the type approaches brown silt loam, it becomes decidedly darker. The organic-matter content averages 2.2 percent, or 22 tons per acre, but it varies considerably with topography. As the type approaches brown silt loam, the organic-matter content amounts to as much as 2.5 percent, while as it approaches yellow silt loam, it diminishes to as low as 1.6 percent. In some places it is difficult to draw the line between long-cultivated brown silt loam and yellow-gray silt loam, because of the gradation between the types.

The subsurface stratum varies from 3 to 10 inches in thickness. It is usually a gray, grayish yellow, or yellow silt loam, somewhat pulverulent, but becoming more coherent and plastic with depth. The organic-matter content is about .9 percent, or 18 tons per acre.

The subsoil is a yellow or mottled grayish yellow, clayey silt or silty clay, somewhat plastic when wet, but friable when only moist, and pervious to water.

Owing to the removal by erosion of part of the loessial material, glacial drift is sometimes encountered at a depth of less than 40 inches. The glacial drift may be locally a very gravelly deposit, but usually it is a slightly gravelly clay.

A few small, level areas of a light gray color occur in this type, and here a tight and more or less compact clayey layer is found at a depth of 16 to 24 inches. None of these areas, however, are large enough to be shown on the map. Consequently they are included in the yellow-gray silt loam.

In the management of this yellow-gray silt loam, one of the most essential points is the maintaining or the increasing of organic matter. This is necessary in order to supply nitrogen and liberate mineral plant food, to give better tilth, to prevent "running together," and on some of the more rolling phases to prevent washing.

Another essential is that the acidity of the soil be neutralized by the application of ground limestone, so that clover, alfalfa, and other legumes may be grown more successfully. The initial application may well be 4 or 5 tons per acre, after which 2 tons per acre every four or five years will be sufficient. Since the soil is poor in phosphorus, this element should be applied, preferably in connection with farm manure or clover plowed under. In permanent systems of farming, fine-ground natural rock phosphate will be found the most economical form in which to supply the phosphorus, altho when prices are normal steamed bone meal or acid phosphate may well be used temporarily until plenty of decaying organic matter can be provided.

For definite results from the most practical field experiments upon typical yellow-gray silt loam, we must go down into "Egypt," where the people of Saline county, especially those in the vicinity of Raleigh and Galatia, have provided the University with a very suitable tract of this type of soil for a permanent experiment field. There, as an average of duplicate trials each year for the four years 1910 to 1913, the crop values from four acres were $27.99 from untreated land, $28.80 where organic manures were applied in proportion to the amount of crops produced, $50.07 where 6 tons per acre of limestone and organic manures were applied, and $51.66 with organic manures, limestone and rock phosphate—the wheat, corn, oats, and clover (or cowpeas or soybeans) grown in the rotation being valued at the lower prices heretofore mentioned. The corresponding values for the next four years[1] were $22.35 with no soil enrichment, $29.22 with organic matter, $54.37 with limestone and organic matter, and $57.27 with organic matter, limestone, and rock phosphate.

Owing to the low supply of organic matter, phosphorus produced almost no benefit, as an average, during the early years; but, with increasing applications of organic matter, the effect of phosphorus may become more apparent in subsequent crops. Of course the full benefit of a four-year rotation cannot be realized during the first four years. The farm manure was applied to one field each year, beginning with 1911, and the fourth field received no manure until the first year of the second rotation. Likewise, crop residues plowed under during the first rotation may not be fully recovered in subsequent increased yields until the second or third rotation period.

More recently the people of White county have furnished the University with a tract of yellow-gray silt loam near Enfield, on which experiments have been started. The crop values from four acres, as an average of the first four years (1913-1916), were $24.64 from unfertilized land, $28.25 with organic manures, $39.10 with manures and limestone, and $45.10 with manures, limestone, and rock phosphate; and the corresponding average values for 1917 were $30.58 with no treatment, $35.08 with organic manures, $83.35 with manures and limestone, and $89.91 with manures, limestone, and phosphate. (These values are based on the higher prices mentioned above and with the exceptions noted, are the averages of data from two systems of farming, which include the use of farm manure in one and of green manures and crop residues in the other.)

While limestone is the material first needed for the economic improvement of the more acid soils of southern Illinois, with organic manures and phosphorus

[1]Wheat was destroyed by hail in 1915, and the test for legumes for 1916 is not in duplicate.

TABLE 13.—CROP YIELDS IN SOIL EXPERIMENTS, ANTIOCH FIELD
YELLOW GRAY SILT LOAM, UNDULATING TIMBERLAND; LATE WISCONSIN GLACIATION

Increase: Bushels or Tons per Acre

For nitrogen	1.2	1.9	−10.0	7.5	6.3	−3.1	−1.3	1.3	−1.6	−14.2	6.9		10.8
For phosphorus	5.0	14.7	−.3	25.5	25.9	3.9	9.3	11.6	3.8	12.8	31.6	.72	24.2
For potassium	3.1	11.3	−3.1	11.4	3.4	3.4	.9	1.8	1.6	−4.2	1.3	.12	4.0
	6.5	9.1	3.4	−20.6	1.9	7.5	−21.8	10.5	−.8	−.4	2.2		−12.9
	10.3	21.9	13.1	−2.6	21.5	14.5	−11.2	20.8	4.6	26.6	22.5		.5
	4.6	6.4	16.0	2.8	6.6	10.5	2.8	−3.3	−3.0	7.2	−15.0		−.3

[1]Crop residues in place of commercial nitrogen after 1911.
[2]Figures in parentheses indicate bushels of seed; the others, tons of hay.
[3]No seed produced: clover plowed under on these plots.

to follow in order, the less acid soils of the central part of the state are first in need of phosphorus, altho organic matter and limestone must also be provided for permanent and best results.

Table 13 shows in detail thirteen years' results from the Antioch soil experiment field located in Lake county on the yellow-gray silt loam of the late Wisconsin glaciation. In acidity this type in Champaign county is intermediate between the similar soils in Saline or White and Lake counties, but no experiment field has been conducted on this important soil type in the early Wisconsin glaciation, in which Champaign county is located.

The Antioch field was started in order to learn as quickly as possible what effect would be produced by the addition to this type of soil, of nitrogen, phosphorus, and potassium, singly and in combination. These elements were all added in commercial form until 1911, after which the use of commercial nitrogen was discontinued and crop residues were substituted in its place. (See report of Urbana field, page 9, for further explanations.) Only a small amount of lime was applied at the beginning, in harmony with the teaching which was common at that time; furthermore, Plot 101 proved to be abnormal, so that no conclusions can be drawn regarding the effect of lime. In order to ascertain the effect produced by additions of the different elements singly, Plot 102 must be regarded as the check plot. Three other comparisons are also possible to determine the effect of each element under different conditions.

As an average of forty tests (four each year for ten years), liberal applications of commercial nitrogen produced a slight decrease in crop values; but as an average of thirteen years each dollar invested in phosphorus paid back \$2.59 (Plot 104), while potassium applied in addition to phosphorus (Plot 108) produced no increase, the crops being valued at the lower prices used in the tabular statement. Thus, while the detailed data show great variation, owing both to some irregularity of soil and to some very abnormal seasons, with three almost

TABLE 14.—VALUE OF CROPS PER ACRE IN THIRTEEN YEARS, ANTIOCH FIELD

Plot	Soil treatment applied	Total value of thirteen crops: Lower prices[1]	Higher prices[2]
101	None	\$193.03	\$270.24
102	Lime	171.06	239.48
103	Lime, nitrogen	178.15	249.40
104	Lime, phosphorus	288.85	404.40
105	Lime, potassium	198.40	277.76
106	Lime, nitrogen, phosphorus	256.31	358.82
107	Lime, nitrogen, potassium	190.77	267.08
108	Lime, phosphorus, potassium	287.65	402.70
109	Lime, nitrogen, phosphorus, potassium	273.18	382.44
110	Nitrogen, phosphorus, potassium	280.88	393.24

Value of Increase per Acre in Thirteen Years

	Lower prices	Higher prices
For nitrogen	\$ 7.09	\$ 9.92
For phosphorus	117.79	164.92
For *nitrogen* and phosphorus over phosphorus	−32.54	−45.58
For *phosphorus* and nitrogen over nitrogen	78.16	109.42
For *potassium*, nitrogen, and phosphorus over nitrogen and phosphorus	16.87	23.62

[1]Wheat at \$1 a bushel, corn at 50 cents, oats at 40 cents, hay at \$10 a ton.
[2]Wheat at \$1.40 a bushel, corn at 70 cents, oats at 56 cents, hay at \$14 a ton.

complete crop failures (1904, 1907, and 1910), yet the general summary strongly confirms the analytical data in showing the need of applying phosphorus, the profit from its use, and the loss in adding potassium. In most cases commercial nitrogen damaged the small grains by causing the crop to lodge; but in those years when a corn yield of 40 bushels or more was secured by the application of phosphorus either alone or with potassium, then the addition of nitrogen produced an increase.

From a comparison of the results from the Urbana, Sibley, and Bloomington fields, we must conclude that better yields are to be secured by providing nitrogen by means of farm manure or legume crops grown in the rotation than by the use of commercial nitrogen, which is evidently too readily available, causing too rapid growth and consequent weakness of straw; and of course the atmosphere is the most economical source of nitrogen where that element is needed for soil improvement in general farming. (See Appendix for detailed discussion of "Permanent Soil Improvement.")

Yellow Silt Loam (935, 1135)

Yellow silt loam covers 3.06 square miles (1,958 acres) and constitutes .31 percent of the entire area of the county. It occurs as hilly and badly eroded land on the inner timber belts adjacent to the streams, usually only in narrow, irregular strips with arms extending up the small valleys. In topography it is very rolling, and in most places so badly broken that it should not be cultivated because of the danger of injury from washing.

The surface soil, 0 to 6⅔ inches, is a yellow or grayish yellow, pulverulent silt loam. It varies greatly in color and texture, owing to recent washing. In places the natural subsoil may be exposed. This exposure gives the surface a decidedly yellow color. When freshly plowed the soil appears yellow or brownish yellow, but when it becomes dry after a rain, it is of a grayish color. In some places the surface soil is formed from glacial drift, but this is only on very limited areas and on the steepest slopes. The organic-matter content is the lowest of any type in the county, averaging only 1.5 percent, or 15 tons per acre.

The subsurface varies from a yellow silt loam to a yellow clayey silt loam, and on the steepest slopes may consist of weathered glacial drift. The thickness of the stratum varies from 5 to 12 inches, depending on the amount of recent erosion. The organic-matter content amounts to only 12 tons per acre.

The subsoil consists normally of a yellow clayey silt, but in some areas it may be composed entirely of glacial drift.

The first and most important thing in the management of this type is the prevention of general surface washing and gullying. If the land is cropped at all, a rotation should be practiced that will require a cultivated crop as little as possible and allow pasture and meadow most of the time. If tilled, the land should be plowed deeply and contours should be followed as nearly as possible in plowing, planting, and cultivating. Furrows should not be made up and down the slopes. Every means should be employed to maintain and increase the organic-matter content. This will help hold the soil and keep it in good phys-

ical condition so that it will absorb a large amount of water and thus diminish the run-off.

Additional treatment recommended for this yellow silt loam is the liberal use of limestone wherever cropping is practiced. This type is quite acid; and the limestone, by correcting the acidity of the soil, is especially beneficial to the clover grown to increase the supply of nitrogen. Where this type has been long cultivated and thus exposed to surface washing, it is particularly deficient in nitrogen; indeed, on such lands the low supply of nitrogen is the factor that first limits the growth of grain crops. This fact is very strikingly illustrated by the results from two-pot culture experiments reported in Tables 15 and 16, and shown photographically in Plates 13 and 14.

In one experiment, a large quantity of the typical worn hill soil was collected from two different places. Each lot of soil was thoroly mixed and put in ten four-gallon jars. Wheat was planted in one series and oats in the other.[1] Ground limestone was added to all the jars except the first and last in each set, those two being retained as control, or check pots. The elements nitrogen, phosphorus, and potassium were added singly and in combination, as shown in Table 15.

As an average the nitrogen applied produced a yield about eight times as large as that secured without the addition of nitrogen. While some variations in yield were to be expected, because of differences in the individuality of seed or other uncontrolled causes, yet there is no doubting the plain lesson taught by these actual trials with growing plants.

The question arises next, where is the farmer to secure this much-needed nitrogen? To purchase it in commercial fertilizers would cost too much; indeed, under average conditions the cost of the nitrogen in such fertilizers is greater than the value of the increase in crop yields.

But there is no need whatever to purchase nitrogen, for the air contains an inexhaustible supply of it, which, under suitable conditions, the farmer can draw upon, not only without cost, but with profit in the getting. Clover, alfalfa, cowpeas, and soybeans are not only worth raising for their own sake, but they have the power to secure nitrogen from the atmosphere if the soil contains the essential minerals and the proper nitrogen-fixing bacteria.

In order to secure further information along this line, another experiment with pot cultures was conducted for several years with the same type of worn hill soil as that used for wheat in the former experiment. The results are reported in Table 16.

To three pots (Nos. 3, 6, and 9) nitrogen was applied in commercial form, at an expense amounting to more than the total value of the crops produced. In three other pots (Nos. 2, 11, and 12) a crop of cowpeas was grown during the late summer and fall and turned under before the wheat or oats were planted. Pots 1 and 8 served for important comparisons. After the second cover crop of cowpeas had been turned under, the yield from Pot 2 exceeded that from Pot 3; and in the subsequent years the legume green manures produced, as an average, rather better results than the commercial nitrogen. This experiment confirms

[1]Soil for wheat pots from loess-covered unglaciated area, and that for oat pots from upper Illinoisan glaciation.

PLATE 18.—WHEAT IN POT-CULTURE EXPERIMENT WITH YELLOW SILT LOAM OF WORN HILL LAND (See Table 15)

TABLE 15.—CROP YIELDS IN POT-CULTURE EXPERIMENTS WITH YELLOW SILT LOAM OF WORN HILL LAND
(Grams per pot)

Pot No.	Soil treatment applied	Wheat	Oats
1	None	3	5
2	Limestone	4	4
3	Limestone, nitrogen	26	45
4	Limestone, phosphorus	3	6
5	Limestone, potassium	3	5
6	Limestone, nitrogen, phosphorus	34	38
7	Limestone, nitrogen, potassium	33	46
8	Limestone, phosphorus, potassium	2	5
9	Limestone, nitrogen, phosphorus, potassium	34	38
10	None	3	5
Average yield with nitrogen		32	42
Average yield without nitrogen		3	5
Average gain for nitrogen		29	37

that reported in Table 15 in showing the very great need of nitrogen for the improvement of this type of soil,—and it also shows that nitrogen need not be purchased but that it can be obtained from the air by growing legume crops and plowing them under as green manure. Of course the soil can be very markedly improved by feeding the legume crops to live stock and returning the resulting farm manure to the land, if legumes are grown frequently enough and if the farm manure produced is sufficiently abundant and is saved and applied with care. As a rule, it is not advisable to try to enrich this type of soil in phosphorus, for with erosion, which is sure to occur to some extent, the phosphorus supply will be renewed from the subsoil.

Probably the best legumes for this type of soil are sweet clover and alfalfa. On soil deficient in organic matter sweet clover grows better than almost any other legume, and the fact that it is a very deep-rooting plant makes it of value in increasing organic matter and preventing washing. Worthless slopes that have been ruined by washing may be made profitable as pasture by growing sweet clover. The blue grass of pastures may well be supplemented by sweet clover

PLATE 14.—WHEAT IN POT-CULTURE EXPERIMENT WITH YELLOW SILT LOAM OF WORN HILL LAND (See Table 16)

TABLE 16.—CROP YIELDS IN POT-CULTURE EXPERIMENT WITH YELLOW SILT LOAM OF WORN HILL LAND AND NITROGEN-FIXING GREEN MANURE CROPS

(Grams per pot)

Pot No.	Soil treatment	1903 Wheat	1904 Wheat	1905 Wheat	1906 Wheat	1907 Oats
1	None	5	4	4	4	6
2	Limestone, legume	10	17	26	10	37
11	Limestone, legume, phosphorus	14	[illegible]	20	18	27
12	Limestone, legume, phosphorus, potassium	16	20	21	19	30
3	Limestone, nitrogen	17	[illegible]	15	9	28
6	Limestone, nitrogen, phosphorus	26	20	18	18	30
9	Limestone, nitrogen, phosphorus, potassium	31	34	21	20	26
8	Limestone, phosphorus, potassium	[illegible]	3	5	3	[illegible]

and alfalfa, and a larger growth obtained, because the legumes provide the necessary nitrogen for the blue grass.

To get alfalfa well started requires the liberal use of limestone, thoro inoculation with the proper nitrogen-fixing bacteria, and a moderate application of farm manure. If manure is not available, it is well to apply about 500 pounds per acre of acid phosphate or steamed bone meal, mix it with the soil, by disking if possible, and then plow it under. The limestone (about 5 tons) should be applied after plowing and should be mixed with the surface soil in the preparation of the seed bed. The special purpose of this treatment is to give the alfalfa a quick start in order that it may grow rapidly and thus protect the soil from washing.

Yellow-Gray Sandy Loam (1164)

A small area of yellow-gray sandy loam, comprizing about 70 acres, occurs near Glover. This was once covered with forest growth.

The surface soil, 0 to 6⅔ inches, is a gray to yellowish gray sandy loam, containing 1.7 percent of organic matter, or 17 tons per acre.

The subsurface soil is a yellow sandy loam somewhat variable in physical composition. It contains .7 percent of organic matter.

The subsoil varies from a yellow clay or clayey silt to a sand.

For the improvement of this type of soil, ground limestone and organic manures are the only materials advised. With the deep feeding range afforded the plant roots, marked improvement can be made without the addition of phosphorus or potassium. The initial application of ground limestone may well be 4 or 5 tons per acre, and 6 or 8 tons will give still better results, especially for the production of alfalfa or sweet clover. Of course large use should be made of legume crops. Cowpeas and soybeans are both good crops for such land; they may be grown and plowed under in place of manure in preparing the land for alfalfa or other crops. (See also pages 482-483 of Bulletin 193, "Summary of Illinois Soil Investigations," which will be sent upon request.)

(c) TERRACE SOILS

Terrace soils were formed on terraces or old fills in valleys. The terraces owe their formation generally to the deposition of material from overloaded and flooded streams during the melting of the glaciers. The material varied from fine to coarse. These valleys were sometimes filled almost to the height of the upland. Later the streams cut down thru these fills and developed new bottom lands, or flood plains, at a lower level, leaving part of the old fill as a terrace. The lowest and most recently formed bottom land is called first bottom. The higher land no longer flooded (or very rarely at most) is generally designated as second bottom. Finer material later deposited on this sand and gravel of the fill now constitutes the soil. The terraces in Champaign county occur mostly along the Salt and Middle Fork, but there are small areas along a few of the other streams.

Yellow-Gray Silt Loam over Sand or Gravel (1536)

Yellow-gray silt loam over sand or gravel occurs in comparatively small areas along all the larger streams. The total area is 2.71 square miles (1,734 acres), or .27 percent of the area of the county. The topography is flat to slightly rolling.

The surface soil, 0 to 6⅔ inches, is a grayish yellow to brownish yellow silt loam, sometimes containing a perceptible amount of sand. It is pulverulent, but not granular. It contains about 2.1 percent of organic matter, or 21 tons per acre.

The subsurface soil is a yellow to brownish yellow silt loam, passing into a yellow silt at 12 to 14 inches. It contains .7 percent of organic matter.

The subsoil is a yellow silt, pervious and friable. The depth to gravel varies from 40 to 50 inches.

This type is well drained. The liberal use of ground limestone and legume crops is most important in its management. An increase of organic matter is very essential, as this constituent is so low that the soil "runs together" badly during rains. Phosphorus must also be applied for the best results.

Brown Silt Loam over Sand or Gravel (1527)

Brown silt loam over sand or gravel occurs principally in the northeastern part of the county along the Middle Fork. A few small areas are found along

the Sangamon and Salt Fork. The total area is 2.41 square miles, or 1,542 acres. The depth to gravel varies from four to five feet, while the stratum of gravel is rarely over five feet thick. The topography is flat to slightly undulating.

The surface soil, 0 to 6⅔ inches, is a brown silt loam with slightly sandy local patches. It is not so dark as the upland brown silt loam, having only 3.6 percent of organic matter, or 36 tons per acre.

The subsurface is a pervious light brown silt loam, changing to yellow silt at a depth of 16 inches.

The subsoil is a yellow, slightly clayey silt, friable and pervious.

The treatment needed for this type is the same as that for upland brown silt loam (926, 1126).

Brown Sandy Loam (1560)

The area of brown sandy loam terrace is only 44 acres. It is lower in organic-matter content than the upland type, having only 1.7 percent. The same suggestion for its management will apply as for upland sandy loam (1160).

(d) Swamp and Bottom-Land Soils

Mixed Loam (1454)

Mixed loam occurs on the flood plains along the courses of the larger streams in Champaign county. With each flood deposits of sediment are left on these plains, thus renewing the soil. The total area of this type is 23.43 square miles (14,995), or 2.37 percent of the area of the county.

The surface soil, 0 to 6⅔ inches, is a black to brown loam, varying from a silt loam to a sandy loam, but so badly mixed that it is impossible to indicate the separate areas on the map. Brown silt loam usually predominates. The organic-matter content averages 5.3 percent, or 53 tons per acre. It varies, however, from about 4.5 percent to 6.5 percent. The surface is usually in fine tilth.

The subsurface soil, 6⅔ to 20 inches, varies as much as the surface, but not necessarily in the same way. It contains 3.3 percent of organic matter.

The subsoil is usually much lighter than the subsurface, but sometimes the dark color extends almost to the full depth of 40 inches. The average amount of organic matter is 1.2 percent. All strata are pervious to water.

Most of this type in the county is in pasture, but, where the areas are sufficiently large, cropping is done, mostly to corn. This soil is usually well supplied with plant food, and, with the renewal by deposit from overflow, no other soil enrichment is advised.

Deep Peat (1401)

A few small areas of deep peat aggregating 90 acres are mapped in Champaign county. They occur in low, poorly drained areas in bottom lands, swamps, or low depressions on the moraines. With a single exception, they occur in the northeastern part of the county in Townships 21 and 22 North, and Ranges 10 and 11 East of 3d P. M., and 14 West of 2d P. M. The area constituting the exception is found in Section 26, Township 20 North, Range 9 East, in what

TABLE 17.—CORN YIELDS IN SOIL EXPERIMENTS, MANITO FIELD; TYPICAL DEEP PEAT SOIL
(Bushels per acre)

Plot No.	Soil treatment for 1902	Corn 1902	Corn 1903	Soil treatment for 1904	Corn 1904	Corn 1905	Four crops
1	None................	10.9	8.1	None................	17.0	12.0	48.0
2	None................	10.4	10.4	Limestone, 4000 lbs....	12.0	10.1	42.9
3	Kainit, 600 lbs.........	30.4	32.4	Limestone, 4000 lbs.. Kainit, 1200 lbs.....	49.6	47.3	159.7
4	Kainit, 600 lbs....... Acidulat'd bone,350 lbs	30.3	33.3	Kainit, 1200 lbs..... Steamed bone,395 lbs.	53.5	47.6	164.7
5	Potassium chlorid, 200 lbs..............	31.2	33.9	Potassium chlorid, 400 lbs.......... ...	48.5	52.7	166.3
6	Sodium chlorid, 700 lbs..	11.1	13.1	None................	24.0	22.1	70.3
7	Sodium chlorid, 700 lbs..	13.3	14.5	Kainit, 1200 lbs.......	44.5	47.3	
8	Kainit, 600 lbs.........	36.8	37.7	Kainit, 600 lbs........	44.0	46.0	164.5
9	Kainit, 300 lbs.........	26.4	25.1	Kainit, 300 lbs........	41.5	32.9	125.9
10	None................	14.9[1]	14.9	None................	26.0	13.6	69.4

[1]Estimated from 1903; no yield was taken in 1902 because of a misunderstanding.

was early known as the Prairie Springs, and these springs were undoubtedly responsible for the formation.

The surface soil, 0 to 6⅔ inches, is black peat, generally well decomposed. About 60 percent of organic matter is present, or 300 tons per acre.

The subsurface is similar to the surface, but it is usually higher in organic matter.

The subsoil varies a great deal. In some cases the deeper subsoil passes into a drab clay. All strata frequently contain fragments of shells mixed with the organic matter.

Drainage is of first importance with this type. This in many cases is rather difficult to secure because tiles cannot be laid to good advantage in peat on account of irregular settling and the consequent displacement of the line. This difficulty may be partly overcome by placing the tiles upon boards laid in the bottom of the ditch, altho such a system cannot be regarded as permanent.

Where thoro drainage can be provided, either by the above method, by open ditches, or by laying tiles deep enough to secure a solid bed for them, very marked improvement can be made in the productive power of deep peat by the liberal use of potassium, which is by far the most deficient element.

In Table 17 are given results obtained from the Manito (Mason county) experiment field on deep peat, which was begun in 1902 and discontinued after 1905. The plots in this field were one acre[1] each in size, 2 rods wide and 80 rods long. Untreated half-rod division strips were left between the plots, which however were cropped the same as the plots.

The results of the four years' tests, as given in Table 17, are in complete harmony with the information furnished by the chemical composition of peat soil. Where potassium was applied, the yield was from three to four times as large as where nothing was applied. Where approximately equal money values of kainit and potassium chlorid were applied, slightly greater yields were obtained with the potassium chlorid, which, however, supplied about one-third more potassium than the kainit. On the other hand, either material furnished more potassium than was required by the crops produced.

[1]In 1904 the yields were taken from quarter-acre plots because of severe insect injury on the other parts of the field.

The use of 700 pounds of sodium chlorid (common salt) produced no appreciable increase over the best untreated plots, indicating that where potassium is itself actually deficient, salts of other elements cannot take its place.

Applications of 2 tons per acre of ground limestone produced no increase in the corn crops, either when applied alone or in combination with kainit, either the first year or the second.

Reducing the application of kainit from 600 to 300 pounds for each two-year period, reduced the yield of corn from 164.5 to 125.9 bushels. The two applications of 300 pounds of kainit (Plot 9) furnished 60 pounds of potassium for the four years, an amount sufficient for 84 bushels of corn (grain and stalks). Attention is called to the fact that this is practically the difference between the yield of Plot 9 (125.9 bushels) and the yield obtained from Plot 2 (42.9 bushels), the poorest untreated plot.

Farm manures and crop residues also contain sufficient potassium to make their use very effective on deep peat soil; and with prohibitive prices for commercial potash salts, farm manure, corn stalks, straw, etc., must be utilized for the improvement of such soils.

Medium Peat on Clay (1402)

One area of medium peat, 19 acres in extent, was found in Champaign county. The peat is about sixteen inches in depth, underlain by a black to drab clay. The surface soil contains 34 percent of organic matter, or 170 tons per acre.

If this type is not productive when well drained, it may be improved by extra deep plowing, by which process the more clayey material can be reached; otherwise the use of manure or commercial potassium is advised. (See treatment recommended for *Deep Peat*.)

APPENDIX

A study of the soil map and the tabular statements concerning crop requirements, the plant-food content of the different soil types, and the actual results secured from definite field trials with different methods or systems of soil improvement, and a careful study of the discussion of general principles and of the descriptions of individual soil types, will furnish the most necessary and useful information for the practical improvement and permanent preservation of the productive power of every kind of soil on every farm in the county.

More complete information concerning the most extensive and important soil types in the great soil areas in all parts of Illinois is contained in Bulletin 123, "The Fertility in Illinois Soils," which contains a colored general soil-survey map of the entire state.

Other publications of general interest are:

Bulletins

76 Alfalfa on Illinois Soils
94 Nitrogen Bacteria and Legumes
115 Soil Improvement for the Worn Hill Lands of Illinois
125 Thirty Years of Crop Rotation on the Common Prairie Lands of Illinois
181 Soil Moisture and Tillage for Corn
182 Potassium from the Soil
190 Soil Bacteria and Phosphates

Circulars

82 Physical Improvement of Soils
110 Ground Limestone for Acid Soils
127 Shall We Use Natural Rock Phosphate or Manufactured Acid Phosphate for the Permanent Improvement of Illinois Soils?
129 The Use of Commercial Fertilizers
149 Results of Scientific Soil Treatment: Methods and Results of Ten Years' Soil Investigation in Illinois
165 Shall We Use "Complete" Commercial Fertilizers in the Corn Belt?
167 The Illinois System of Permanent Fertility
181 How Not to Treat Illinois Soils
186 The Illinois System of Permanent Fertility from the Standpoint of the Practical Farmer: Phosphates and Honesty

NOTE.—Information as to where to obtain limestone, phosphate, bone meal, and potassium salts, methods of application, etc., will also be found in Circulars 110 and 165.

SOIL SURVEY METHODS

The detail soil survey of a county consists essentially of ascertaining, and indicating on a map, the location and extent of the different soil types; and, since the value of the survey depends upon its accuracy, every reasonable means is employed to make it trustworthy. To accomplish this object three things are essential: first, careful, well-trained men to do the work; second, an accurate base map upon which to show the results of the work; and, third, the means necessary to enable the men to place the soil-type boundaries, streams, etc., accurately upon the map.

The men selected for the work must be able to keep their location exactly and to recognize the different soil types, with their principal variations and limits, and they must show these upon the maps correctly. A definite system is employed in checking up this work. As an illustration, one soil expert will survey and map a strip 80 rods or 160 rods wide and any convenient length, while

his associate will work independently on another strip adjoining this area, and, if the work is correctly done, the soil type boundaries will match up on the line between the two strips.

An accurate base map for field use is absolutely necessary for soil mapping. The base maps are made on a scale of one inch to the mile. The official data of the original or subsequent land survey are used as a basis in the construction of these maps, while the most trustworthy county map available is used in locating temporarily the streams, roads, and railroads. Since the best of these published maps have some inaccuracies, the location of every road, stream, and railroad must be verified by the soil surveyors, and corrected if wrongly located. In order to make these verifications and corrections, each survey party is provided with a plane table for determining directions of angling roads, railroads, etc.

Each surveyor is provided with a base map of the proper scale, which is carried with him in the field; and the soil-type boundaries, ditches, streams, and necessary corrections are placed in their proper locations upon the map while the mapper is on the area. Each section, or square mile, is divided into 40-acre plots on the map, and the surveyor must inspect every ten acres and determine the type or types of soil composing it. The different types are indicated on the map by different colors, pencils for this purpose being carried in the field.

A small auger 40 inches long forms for each man an invaluable tool with which he can quickly secure samples of the different strata for inspection. An extension for making the auger 80 inches long is carried by each party, so that any peculiarity of the deeper subsoil layers may be studied. Each man carries a compass to aid in keeping directions. Distances along roads are measured by an odometer attached to the axle of the vehicle, while distances in the field off the roads are determined by pacing, an art in which the men become expert by practice. The soil boundaries can thus be located with as high a degree of accuracy as can be indicated by pencil on the scale of one inch to the mile.

Soil Characteristics

The unit in the soil survey is the soil type, and each type possesses more or less definite characteristics. The line of separation between adjoining types is usually distinct, but sometimes one type grades into another so gradually that it is very difficult to draw the line between them. In such exceptional cases, some slight variation in the location of soil-type boundaries is unavoidable.

Several factors must be taken into account in establishing soil types. These are: (1) the geological origin of the soil, whether residual, glacial, loessial, alluvial, colluvial, or cumulose; (2) the topography, or lay of the land; (3) the native vegetation, as forest or prairie grasses; (4) the structure, or the depth and character of the surface, subsurface, and subsoil; (5) the physical, or mechanical composition of the different strata composing the soil, such as the percentages of gravel, sand, silt, clay, and organic matter which they contain; (6) the texture, or porosity, granulation, friability, plasticity, etc.; (7) the color of the strata; (8) the natural drainage; (9) the agricultural value, based upon its natural productiveness; (10) the ultimate chemical composition and reaction.

Tho common soil constituents are indicated in the following outline:

Soil constituents	Organic matter	Comprizing undecomposed and partially decayed vegetable or organic material	
	Mineral matter	Clay	.001 mm.[1] and less
		Silt	.001 mm. to .03 mm.
		Sand	.03 mm. to 1. mm.
		Gravel	1. mm. to 32 mm.
		Stones	32. mm. and over

Further discussion of these constituents is given in Circular 82.

GROUPS OF SOIL TYPES

The following gives the different general groups of soils:

Peats—Consisting of 35 percent or more of organic matter, sometimes mixed with more or less sand or silt.

Peaty loams—Soils with 15 to 35 percent of organic matter mixed with much sand. Some silt and a little clay may be present.

Mucks—Soils with 15 to 35 percent of partly decomposed organic matter mixed with much clay and silt.

Clays—Soils with more than 25 percent of clay, usually mixed with much silt.

Clay loams—Soils with from 15 to 25 percent of clay, usually mixed with much silt and some sand.

Silt loams—Soils with more than 50 percent of silt and less than 15 percent of clay, mixed with some sand.

Loams—Soils with from 30 to 50 percent of sand mixed with much silt and a little clay.

Sandy loams—Soils with from 50 to 75 percent of sand.

Fine sandy loams—Soils with from 50 to 75 percent of fine sand mixed with much silt and a little clay.

Sands—Soils with more than 75 percent of sand.

Gravelly loams—Soils with 25 to 50 percent of gravel with much sand and some silt.

Gravels—Soils with more than 50 percent of gravel and much sand.

Stony loams—Soils containing a considerable number of stones over one inch in diameter.

Rock outcrop—Usually ledges of rock having no direct agricultural value.

More or less organic matter is found in all the above groups.

SUPPLY AND LIBERATION OF PLANT FOOD

The productive capacity of land in humid sections depends almost wholly upon the power of the soil to feed the crop; and this, in turn, depends both upon the stock of plant food contained in the soil and upon the rate at which it is liberated, or rendered soluble and available for use in plant growth. Protection from weeds, insects, and fungous diseases, tho exceedingly important, is not a positive but a negative factor in crop production.

The chemical analysis of the soil gives the invoice of fertility actually present in the soil strata sampled and analyzed, but the rate of liberation is governed by many factors, some of which may be controlled by the farmer, while others are largely beyond his control. Chief among the important controllable factors which influence the liberation of plant food are limestone and decaying organic matter, which may be added to the soil by direct application of ground limestone and farm manure. Organic matter may be supplied also by green-manure crops and crop residues, such as clover, cowpeas, straw, and corn stalks.

[1]25 millimeters equal 1 inch.

The rate of decay of organic matter depends largely upon its age and origin, and it may be hastened by tillage. The chemical analysis shows correctly the total organic carbon, which represents, as a rule, but little more than half the organic matter; so that 20,000 pounds of organic carbon in the plowed soil of an acre correspond to nearly 20 tons of organic matter. But this organic matter consists largely of the old organic residues that have accumulated during the past centuries because they were resistant to decay, and 2 tons of clover or cowpeas plowed under may have greater power to furnish or liberate plant food than the 20 tons of old, inactive organic matter. The recent history of the individual farm or field must be depended upon for information concerning recent additions of active organic matter, whether in applications of farm manure, in legume crops, or in grass-root sods of old pastures.

Probably no agricultural fact is more generally known by farmers and landowners than that soils differ in productive power. Even tho plowed alike and at the same time, prepared the same way, planted the same day with the same kind of seed, and cultivated alike, watered by the same rains and warmed by the same sun, nevertheless the best acre may produce twice as large a crop as the poorest acre on the same farm, if not, indeed, in the same field; and the fact should be repeated and emphasized that with the normal rainfall of Illinois the productive power of the land depends primarily upon the stock of plant food contained in the soil and upon the rate at which it is liberated, just as the success of the merchant depends primarily upon his stock of goods and the rapidity of sales. In both cases the stock of any commodity must be increased or renewed whenever the supply of such commodity becomes so depleted as to limit the success of the business, whether on the farm or in the store.

As the organic matter decays, certain decomposition products are formed, including much carbonic acid, some nitrous acid, and various organic acids, and these have power to act upon the soil and dissolve the essential mineral plant foods, thus furnishing soluble phosphates, nitrates, and other salts of potassium, magnesium, calcium, etc., for the use of the growing crop.

As already explained, fresh organic matter decomposes much more rapidly than old humus, which represents the organic residues most resistant to decay and which consequently has accumulated in the soil during the past centuries. The decay of this old humus can be hastened by tillage, which maintains a porous condition and thus permits the oxygen of the air to enter the soil more freely and to effect the more rapid oxidation of the organic matter, and also by incorporating with the old, resistant residues some fresh organic matter, such as farm manure, clover roots, etc., which decay rapidly and thus furnish, or liberate, organic and inorganic food for bacteria, the bacteria, under such favorable conditions, appearing to have power to attack and decompose the old humus. It is probably for this reason that peat, a very inactive and inefficient fertilizer when used by itself, becomes much more effective when composted with fresh farm manure; so that two tons of the compost[1] may be worth as much as two tons of manure. Bacterial action is also promoted by the presence of limestone.

[1]In his book, "Fertilizers," published in 1839, Cuthbert W. Johnson reported such compost to have been much used in England and to be valued as highly, "weight for weight, as farmyard dung."

The condition of the organic matter of the soil is indicated more or less definitely by the ratio of carbon to nitrogen. As an average, the fresh organic matter incorporated with soils contains about twenty times as much carbon as nitrogen, but the carbohydrates ferment and decompose much more rapidly than the nitrogenous matter; and the old resistant organic residues, such as are found in normal subsoils, commonly contain only five or six times as much carbon as nitrogen. Soils of normal physical composition, such as loam, clay loam, silt loam, and fine sandy loam, when in good productive condition, contain about twelve to fourteen times as much carbon as nitrogen in the surface soil; while in old, worn soils that are greatly in need of fresh, active, organic manures, the ratio is narrower, sometimes falling below ten of carbon to one of nitrogen. Soils of cut-over or burnt-over timber lands sometimes contain so much partially decayed wood or charcoal as to destroy the value of the nitrogen-carbon ratio for the purpose indicated. (Except in newly made alluvial soils, the ratio is usually narrower in the subsurface and subsoil than in the surface stratum.)

It should be kept in mind that crops are *not* made out of nothing. They are composed of ten different elements of plant food, every one of which is absolutely essential for the growth and formation of every agricultural plant. Of these ten elements of plant food, only two (carbon and oxygen) are secured from the air by all agricultural plants, only one (hydrogen) from water, and seven from the soil. Nitrogen, one of these seven elements secured from the soil by all plants, may also be secured from the air by one class of plants (legumes), in case the amount liberated from the soil is insufficient; but even these plants (which include only the clovers, alfalfa, peas, beans, and vetches, among our common agricultural plants) secure from the soil alone six elements (phosphorus, potassium, magnesium, calcium, iron, and sulfur), and also utilize the soil nitrogen so far as it becomes soluble and available during their period of growth.

Plants are made of plant-food elements in just the same sense that a building is made of wood and iron, brick, stone, and mortar. Without materials, nothing material can be made. The normal temperature, sunshine, rainfall, and length of season in central Illinois are sufficient to produce 50 bushels of wheat per acre, 100 bushels of corn, 100 bushels of oats, and 4 tons of clover hay; and, where the land is properly drained and properly tilled, such crops would frequently be secured *if the plant foods were present in sufficient amounts and liberated at a sufficiently rapid rate to meet the absolute needs of the crops.*

CROP REQUIREMENTS

The accompanying table shows the requirements of wheat, corn, oats, and clover for the five most important plant-food elements which the soil must furnish. (Iron and sulfur are supplied normally in sufficient abundance compared with the amounts needed by plants, so that they are never known to limit the yield of general farm crops grown under normal conditions.)

To be sure, these are large yields, but shall we try to make possible the production of yields only a half or a quarter as large as these, or shall we set as our ideal this higher mark, and then approach it as nearly as possible with profit? Among the four crops, corn is the largest, with a total yield of more than six tons per acre; and yet the 100-bushel crop of corn is often produced

TABLE A.—PLANT FOOD IN WHEAT, CORN, OATS, AND CLOVER

Produce		Nitrogen	Phosphorus	Potassium	Magnesium	Calcium
Kind	Amount					
		lbs.	*lbs.*	*lbs.*	*lbs.*	*lbs.*
Wheat, grain	50 bu.	71	12	13	4	1
Wheat straw	2½ tons	25	4	45	4	10
Corn, grain	100 bu.	100	17	19	7	1
Corn stover	3 tons	48	6	52	10	21
Corn cobs	½ ton	2		2		
Oats, grain	100 bu.	66	11	16	4	2
Oat straw	2½ tons	31	5	52	7	15
Clover seed	4 bu.	7	2	3	1	1
Clover hay	4 tons	160	20	120	31	117
Total in grain and seed		244[1]	42	51	16	4
Total in four crops		510[1]	77	322	68	168

[1]These amounts include the nitrogen contained in the clover seed or hay, which, however, may be secured from the air.

on rich land in good seasons. In very practical and profitable systems of farming, the Illinois Experiment Station has produced, as an average of the ten years 1906 to 1915, a yield of 77 bushels of corn per acre in grain farming (with limestone and phosphorus applied, and with crop residues and legume crops turned under), and 79 bushels per acre in live-stock farming (with limestone phosphorus, and manure).

The importance of maintaining a rich surface soil cannot be too strongly emphasized. This is well illustrated by data from the Rothamsted Experiment Station, the oldest in the world. On Broadbalk field, where wheat has been grown since 1844, the average yields for the ten years 1892 to 1901 were 12.3 bushels per acre on Plot 3 (unfertilized) and 31.8 bushels on Plot 7 (well fertilized), but the amounts of both nitrogen and phosphorus in the subsoil (9 to 27 inches) were distinctly greater in Plot 3 than in Plot 7, thus showing that the higher yields from Plot 7 were due to the fact that the plowed soil had been enriched. In 1893 Plot 7 contained per acre in the surface soil (0 to 9 inches) about 600 pounds more nitrogen and 900 pounds more phosphorus than Plot 3. Even a rich subsoil has little value if it lies beneath a worn-out surface.

METHODS OF LIBERATING PLANT FOOD

Limestone and decaying organic matter are the principal materials which the farmer can utilize most profitably to bring about the liberation of plant food. The limestone corrects the acidity of the soil and thus encourages the development not only of the nitrogen-gathering bacteria which live in the nodules on the roots of clover, cowpeas, and other legumes, but also the nitrifying bacteria, which have power to transform the insoluble and unavailable organic nitrogen into soluble and available nitrate nitrogen. At the same time, the products of this decomposition have power to dissolve the minerals contained in the soil, such as potassium and magnesium, and also to dissolve the insoluble phosphate and limestone which may be applied in low-priced forms. Thus, in the conversion of sufficient organic nitrogen into nitrate nitrogen for a 100-bushel crop of corn, the nitrous acid formed is alone sufficient to convert seven times as much insoluble tricalcium phosphate into soluble monocalcium phosphate as would be required to supply the phosphorus for the same crop.

Tillage, or cultivation, also hastens the liberation of plant food by permitting the air to enter the soil and burn out the organic matter; but it should never be forgotten that tillage is wholly destructive, that it adds nothing whatever to the soil, but always leaves it poorer. Tillage should be practiced so far as is necessary to prepare a suitable seed bed for root development and also for the purpose of killing weeds, but more than this is unnecessary and unprofitable in seasons of normal rainfall; and it is much better actually to enrich the soil by proper applications or additions, including limestone and organic matter (both of which have power to improve the physical condition as well as to liberate plant food) than merely to hasten soil depletion by means of excessive cultivation.

PERMANENT SOIL IMPROVEMENT

The best and most profitable methods for the permanent improvement of the common soils of Illinois are as follows:

(1) If the soil is acid, apply at least two tons per acre of ground limestone, preferably at times magnesian limestone ($CaCO_3MgCO_3$), which contains both calcium and magnesium and has slightly greater power to correct soil acidity, ton for ton, than the ordinary calcium limestone ($CaCO_3$); and continue to apply about two tons per acre of ground limestone every four or five years. On strongly acid soils, or on land being prepared for alfalfa, five tons per acre of ground limestone may well be used for the first application.

(2) Adopt a good rotation of crops, including a liberal use of legumes, and increase the organic matter of the soil either by plowing under the legume crops and other crop residues (straw and corn stalks), or by using for feed and bedding practically all the crops raised and returning the manure to the land with the least possible loss. No one can say in advance what will prove to be the best rotation of crops, because of variation in farms and farmers and in prices for produce, but the following are suggested to serve as models or outlines:

First year, corn.
Second year, corn.
Third year, wheat or oats (with clover or clover and grass).
Fourth year, clover or clover and grass.
Fifth year, wheat and clover or grass and clover.
Sixth year, clover or clover and grass.

Of course there should be as many fields as there are years in the rotation. In grain farming, with small grain grown the third and fifth years, most of the coarse products should be returned to the soil, and the clover may be clipped and left on the land or returned after threshing (only the clover seed being sold the fourth and sixth years); or, in live-stock farming, the field may be used three years for timothy and clover pasture and meadow if desired. The system may be reduced to a five-year rotation by cutting out either the second or the sixth year, and to a four-year system by omitting the fifth and sixth years.

With two years of corn, followed by oats with clover-seeding the third year, and by clover the fourth year, all produce can be used for feed and bedding if other land is available for permanent pasture. Alfalfa may be grown on a fifth field for four or eight years, which is to be alternated with one of the four; or the alfalfa may be moved every five years, and thus rotated over all five fields every twenty-five years.

Other four-year rotations more suitable for grain farming are:

Wheat (and clover), corn, oats, and clover; or corn (and clover), cowpeas, wheat, and clover. (Alfalfa may be grown on a fifth field and rotated every five years, the hay being sold.)

Good three-year rotations are:

Corn, oats, and clover; corn, wheat, and clover; or wheat (and clover), corn, (and clover), and cowpeas, in which two cover crops and one regular crop of legumes are grown in three years.

A five-year rotation of (1) corn (and clover), (2) cowpeas, (3) wheat, (4) clover, and (5) wheat (and clover) allows legumes to be seeded four times. Alfalfa may be grown on a sixth field for five or six years in the combination rotation, alternating between two fields every five years, or rotating over all the fields if moved every six years.

For the best production of seed in grain farming, alsike, sweet clover, or mammoth clover may well be grown. To avoid clover "sickness" it may sometimes be necessary to substitute sweet clover or alsike for red clover in about every third rotation, and at the same time to discontinue its use in the cover-crop mixture. If the corn crop is not too rank, cowpeas or soybeans may also be used as a cover crop (seeded at the last cultivation) in the southern part of the state, and, if necessary to avoid disease (such as cowpea wilt) these may alternate in successive rotations.

For easy figuring it may well be kept in mind that the following amounts of nitrogen are required for the produce named:

1 bushel of oats (grain and straw) requires one pound of nitrogen.
1 bushel of corn (grain and stalks) requires 1½ pounds of nitrogen.
1 bushel of wheat (grain and straw) requires 2 pounds of nitrogen.
1 ton of timothy requires 24 pounds of nitrogen.
1 ton of clover contains 40 pounds of nitrogen.
1 ton of cowpeas contains 43 pounds of nitrogen.
1 ton of average manure contains 10 pounds of nitrogen.

The roots of clover contain about half as much nitrogen as the tops, and the roots of cowpeas contain about one-tenth as much as the tops.

Soils of moderate productive power will furnish as much nitrogen to clover (and two or three times as much to cowpeas) as will be left in the roots and stubble. In grain crops, such as wheat, corn, and oats, about two-thirds of the nitrogen is contained in the grain and one-third in the straw or stalks. (See also discussion of "The Potassium Problem," on pages following.)

(3) On all lands deficient in phosphorus (except on those susceptible to serious erosion by surface washing or gullying) apply that element in considerably larger amounts than are required to meet the actual needs of the crops desired to be produced. The abundant information thus far secured shows positively that fine-ground natural rock phosphate can be used successfully and very profitably, and clearly indicates that this material will be the most economical form of phosphorus to use in all ordinary systems of permanent, profitable soil improvement. The first application may well be one ton per acre, and subsequently from one-half ton to one ton per acre every four or five years should be applied, at least until the phosphorus content of the plowed soil reaches 2,000 pounds per acre, which may require a total application of from three to five or six tons per acre of raw phosphate containing 12 to 14 percent of the element phosphorus.

Steamed bone meal and even acid phosphate may be used in emergencies, but it should always be kept in mind that phosphorus delivered in Illinois has normally cost about 3 cents a pound in raw phosphate (direct from the mine in carload lots), but 10 to 12 cents a pound in steamed bone meal and acid phosphate, both of which cost too much per ton to permit their common purchase by farmers in carload lots, which is not the case with limestone or raw phosphate.

Phosphorus once applied to the soil remains in it until removed in crops, unless carried away mechanically by soil erosion. (The loss by leaching is only about 1½ pounds per acre per annum, so that more than 150 years would be required to leach away the phosphorus applied in one ton of raw phosphate.)

The phosphate and limestone may be applied at any time during the rotation, but a good method is to apply the limestone after plowing and work it into the surface soil in preparing the seed bed for wheat, oats, rye, or barley, where clover is to be seeded; while phosphate is best plowed under with farm manure, clover, or other green manures, which serve to liberate the phosphorus.

(4) Until the supply of decaying organic matter has been made adequate, on the poorer types of upland timber and gray prairie soils some temporary benefit may be derived from the use of a soluble salt or a mixture of salts, such as kainit, which contains both potassium and magnesium in soluble form and also some common salt (sodium chlorid). About 600 to 800 pounds per acre of kainit applied and turned under with the raw phosphate will help to dissolve the phosphorus as well as to furnish available potassium and magnesium, and for a few years such use of kainit may be profitable on lands deficient in organic matter, but the evidence thus far secured indicates that its use is not absolutely necessary and that it will not be profitable after adequate provision is made for supplying decaying organic matter, since this will necessitate returning to the soil the potassium contained in the crop residues from grain farming or the manure produced in live-stock farming, and will also provide for the liberating of potassium from the soil. (Where hay or straw is sold, manure should be bought, as a rule.)

On soils which are subject to surface washing, including especially the yellow silt loam of the upland timber area, and to some extent the yellow-gray silt loam and other more rolling areas, the supply of minerals in the subsurface and subsoil (which gradually renew the surface soil) tends to provide for a low-grade system of permanent agriculture if some use is made of legume plants, as in long rotations with much pasture, because both the minerals and the nitrogen are thus provided in some amount almost permanently; but where such lands are farmed under such a system, not more than two or three grain crops should be grown during a period of ten or twelve years, the land being kept in pasture most of the time; and where the soil is acid a liberal use of limestone, as top-dressings if necessary, and occasional reseeding with clovers will benefit both the pasture and indirectly the grain crops.

ADVANTAGE OF CROP ROTATION AND PERMANENT SYSTEMS

It should be noted that clover is not likely to be well infected with the clover bacteria during the first rotation on a given farm or field where it has not been grown before within recent years; but even a partial stand of clover the first time will probably provide a thousand times as many bacteria for the

next clover crop as one could afford to apply in artificial inoculation, for a single root-tubercle may contain a million bacteria developed from one during the season's growth.

This is only one of several advantages of the second course of the rotation over the first course. The mere practice of crop rotation is an advantage, especially in helping to rid the land of insects and foul grass and weeds. The clover crop is an advantage to subsequent crops because of its deep-rooting characteristic. The larger applications of organic manures (made possible by the larger crops) are a great advantage; and in systems of permanent soil improvement, such as are here advised and illustrated, more limestone and more phosphorus are provided than are needed for the meager or moderate crops produced during the first rotation, and consequently the crops in the second rotation have the advantage of such accumulated residues (well incorporated with the plowed soil) in addition to the regular applications made during the second rotation.

This means that these systems tend positively toward the making of richer lands. The ultimate analyses recorded in the tables give the absolute invoice of these Illinois soils. They show that most of them are positively deficient only in limestone, phosphorus, and nitrogenous organic matter; and the accumulated information from careful and long-continued investigations in different parts of the United States clearly establishes the fact that in general farming these essentials can be supplied with greatest economy and profit by the use of ground natural limestone, very finely ground natural rock phosphate, and legume crops to be plowed under directly with other crop residues or in farm manure. On normal soils no other applications are absolutely necessary, but, as already explained, the addition of some soluble salt in the beginning of a system of improvement on some of these soils produces temporary benefit, and if some inexpensive salt, such as kainit, is used, it may produce sufficient increase to more than pay the added cost.

THE POTASSIUM PROBLEM

As reported in Illinois Bulletin 123, where wheat has been grown every year for more than half a century at Rothamsted, England, exactly the same increase was produced (5.6 bushels per acre), as an average of the first twenty-four years, whether potassium, magnesium, or sodium was applied, the rate of application per annum being 200 pounds of potassium sulfate and molecular equivalents of magnesium sulfate and sodium sulfate. As an average of sixty years (1852 to 1911), the yield of wheat was 12.7 bushels on untreated land and 23.3 bushels where 86 pounds of nitrogen and 29 pounds of phosphorus per acre per annum were applied. As further additions, 85 pounds of potassium raised the yield to 31.3 bushels; 52 pounds of magnesium raised it to 29.2 bushels; and 50 pounds of sodium raised it to 29.5 bushels. Where potassium was applied, the wheat crop removed annually an average of 40 pounds of that element in the grain and straw, or three times as much as would be removed in the grain only for such crops as are suggested in Table A. The Rothamsted soil contained an abundance of limestone, but no organic matter was provided except the little in the stubble and roots of the wheat plants.

On another field at Rothamsted the average yield of barley for sixty years (1852 to 1911) was 14.2 bushels on untreated land, 38.1 bushels where 43 pounds of nitrogen and 29 pounds of phosphorus were applied per acre per annum; while the further addition of 85 pounds of potassium, 19 pounds of magnesium, and 14 pounds of sodium (all in sulfates) raised the average yield to 41.5 bushels. Where only 70 pounds of sodium was applied in addition to the nitrogen and phosphorus, the average was 43.0 bushels. Thus, as an average of sixty years the use of sodium produced 1.8 bushels less wheat and 1.5 bushels more barley than the use of potassium, with both grain and straw removed and no organic manures returned.

In recent years the effect of potassium on the wheat crop is becoming much more marked than that of sodium or magnesium; but this must be expected to occur in time where no potassium is returned in straw or manure and no provision made for liberating potassium from the supply still remaining in the soil.

If the wheat straw, which contains more than three-fourths of the potassium removed in the wheat crop (see Table A), were returned to the soil, the necessity of purchasing potassium in a good system of farming on such land would be at least very remote, for the supply would be adequately maintained by the actual amount returned in the straw, together with the additional amount which would be liberated from the soil by the action of decomposition products.

While about half the potassium, nitrogen, and organic matter, and about one-fourth the phosphorus contained in manure is lost by three or four months' exposure in the ordinary pile in the barn yard, there is practically no loss if plenty of absorbent bedding is used on cement floors and if the manure is hauled to the field and spread within a day or two after it is produced. Again, while in average live-stock farming the animals destroy two-thirds of the organic matter and retain one-fourth of the nitrogen and phosphorus from the food they consume, they retain less than one-tenth of the potassium; so that the actual loss of potassium in the products sold from the farm, either in grain farming or in live-stock farming, is wholly negligible on land containing 25,000 pounds or more of potassium in the surface 6⅔ inches.

The removal of one inch of soil per century by surface washing (which is likely to occur wherever there is satisfactory surface drainage and frequent cultivation) will permanently maintain the potassium in grain farming by renewal from the subsoil, provided one-third of the potassium is removed by cropping before the soil is carried away.

From all these facts it will be seen that the potassium problem is not one of addition but of liberation; and the Rothamsted records show that for many years other soluble salts have practically the same power as potassium to increase crop yields in the absence of sufficient decaying organic matter. Whether this action relates to supplying or liberating potassium for its own sake, or to the power of the soluble salt to increase the availability of phosphorus or other elements, is not known, but where much potassium is removed, as in the entire crops at Rothamsted, with no return of organic residues, probably the soluble salt functions in both ways.

As an average of 112 separate tests conducted in 1907, 1908, 1909, and 1910 on the Fairfield experiment field in Wayne county, an application of 200 pounds

of potassium sulfate, containing 85 pounds of potassium and costing $5.10, increased the yield of corn by 9.3 bushels per acre; while 600 pounds of kainit, containing only 60 pounds of potassium and costing $4, gave an increase of 10.7 bushels. Thus, at 40 cents a bushel for corn, the kainit paid for itself; but these results, like those at Rothamsted, were secured where no adequate provision had been made for decaying organic matter.

Additional experiments at Fairfield included an equally complete test with potassium sulfate and kainit on land to which 8 tons per acre of farm manure was applied. As an average of 112 tests with each material, the 200 pounds of potassium sulfate increased the yield of corn by 1.7 bushels, while the 600 pounds of kainit also gave an increase of 1.7 bushels. Thus, where organic manure was supplied, very little effect was produced by the addition of either potassium sulfate or kainit, in part perhaps because the potassium removed in the crops is mostly returned in the manure if properly cared for, and perhaps in larger part because the decaying organic matter helps to liberate and hold in solution other plant-food elements, especially phosphorus.

In laboratory experiments at the Illinois Experiment Station, it has been shown by chemical analysis that potassium salts and most other soluble salts increase the solubility of the phosphorus in soil and in rock phosphate; also that the addition of glucose with rock phosphate in pot-culture experiments increases the availability of the phosphorus, as measured by plant growth, altho the glucose consists only of carbon, hydrogen, and oxygen, and thus contains no plant food of value, but its decomposition yields organic acids.

If we remember that, as an average, live-stock destroy two-thirds of the organic matter of the food they consume, it is easy to determine from Table A that more organic matter will be supplied in a proper grain system than in a strictly live-stock system; and the evidence thus far secured from older experiments at the University and at other places in the state indicates that if the corn stalks, straw, clover, etc., are incorporated with the soil as soon as practicable after they are produced (which can usually be done in the late fall or early spring), there is little or no difficulty in securing sufficient decomposition in our humid climate to avoid serious interference with the capillary movement of the soil moisture, a common danger from plowing under too much coarse manure of any kind in the late spring of a dry year.

If, however, the entire produce of the land is sold from the farm, as in hay farming or when both grain and straw are sold, of course the draft on potassium will then be so great that in time it must be renewed by some sort of application. As a rule, farmers following this practice ought to secure manure from town, since they furnish the bulk of the material out of which manure is produced.

CALCIUM AND MAGNESIUM

When measured by the actual crop requirements for plant food, magnesium and calcium are more limited in some Illinois soils than potassium; and with these elements we must also consider the loss by leaching. As an average of 90 analyses[1] of Illinois well-waters drawn chiefly from glacial sands, gravels, or till,

[1]Reported by Doctor Bartow and associates, of the Illinois State Water Survey.

3 million pounds of water (about the average annual drainage per acre for Illinois) contained 11 pounds of potassium, 130 of magnesium, and 330 of calcium. These figures are very significant, and it may be stated that if the plowed soil is well supplied with the carbonates of magnesium and calcium, then a very considerable proportion of these amounts will be leached from that stratum. Thus the loss of calcium from the plowed soil of an acre at Rothamsted, England, where the soil contains plenty of limestone, has averaged more than 300 pounds a year as determined by analyzing the soil in 1865 and again in 1905. Practically the same amount of calcium was found, by analyses, in the Rothamsted drainage waters.

Common limestone, which is calcium carbonate ($CaCO_3$), contains, when pure, 40 percent of calcium, so that 800 pounds of limestone are equivalent to 320 pounds of calcium. Where 10 tons per acre of ground limestone was applied at Edgewood, Illinois, the average annual loss during the next ten years amounted to 780 pounds per acre. The definite data from careful investigations seem to be ample to justify the conclusion that where limestone is needed at least 2 tons per acre should be applied every four or five years.

It is of interest to note that thirty crops of clover of four tons each would require 3,510 pounds of calcium, while the most common prairie land of southern Illinois contains only 3,420 pounds of total calcium in the plowed soil of an acre. (See Soil Report No. 1.) Thus limestone has a positive value on some soils for the plant food which it supplies, in addition to its value in correcting soil acidity and in improving the physical condition of the soil. Ordinary limestone (abundant in the southern and western parts of the state) contains nearly 800 pounds of calcium per ton; while a good grade of dolomitic limestone (the more common limestone of northern Illinois) contains about 400 pounds of calcium and 300 pounds of magnesium per ton. Both of these elements are furnished in readily available form in ground dolomitic limestone.

PHYSICAL IMPROVEMENT OF SOILS

In the management of most soil types, one very important thing, aside from proper fertilization, tillage, and drainage, is to keep the soil in good physical condition, or good tilth. The constituent most important for this purpose is organic matter. Not only does it impart good tilth to the soil, but it prevents much loss by washing on rolling land, warms the soil by absorption of heat, retains moisture during drouth, and prevents the soil from running together badly; and as it decays it furnishes nitrogen for the crop and aids in the liberation of mineral plant food. This constituent must be supplied to the soil in every practical way, so that the amount may be maintained or even increased. It is being broken down during a large part of the year, and the nitrates produced are used for plant growth. This decomposition is necessary, but it is also quite necessary that the supply be maintained.

The physical effect of organic matter in the soil is to produce a granulation, or mellowness, very favorable for tillage and the development of plant roots. If continuous cropping takes place, accompanied with the removal or the destruction of the corn stalks and straw, the amount of organic matter is gradually diminished and a condition of poor tilth will ultimately follow. In many cases

this already limits the crop yields. The remedy is to increase the organic-matter content by plowing under manure or crop residues, such as corn stalks, straw, and clover. Selling these products from the farm, burning them, or feeding them and not returning the manure, or allowing a very large part of the manure to be lost before it is returned to the land, all represent bad practice.

One of the chief sources of loss of organic matter in the corn belt is the practice of burning the corn stalks. Could the farmers be made to realize how great a loss this entails, they would certainly discontinue the practice. Probably no form of organic matter acts more beneficially in producing good tilth than corn stalks. It is true that they decay rather slowly, but it is also true that their durability in the soil after partial decomposition is exactly what is needed in the maintenance of an adequate supply of humus. The nitrogen in a ton of corn stalks is 1½ times that in a ton of manure, and a ton of dry corn stalks incorporated with the soil will ultimately furnish as much humus as 4 tons of average farm manure; but when burned, both the humus-making material and the nitrogen which these stalks contain are destroyed and lost to the soil.

The objection is often raised that when stalks are plowed under they interfere very seriously in the cultivation of corn, and thus indirectly destroy a great deal of corn. If corn stalks are well cut up and then turned under to a depth of 5½ to 6 inches when the ground is plowed in the spring, very little trouble will result. Where corn follows corn, the stalks, if not needed for feeding purposes, should be thoroly cut up with a sharp disk or stalk cutter and turned under. Likewise, the straw should be returned to the land in some practical way, either directly or as manure. Clover should be one of the crops grown in the rotation, and it should be plowed under directly or as manure instead of being sold as hay, except when manure can be brought back.

It must be remembered, however, that in the feeding of hay, or straw, or corn stalks, a great destruction of organic matter takes place, so that even if the fresh manure were returned to the soil, there would still be a loss of 50 to 70 percent owing to the destruction of organic matter by the animal. If manure is allowed to lie in the farmyard for a few weeks or months, there is an additional loss which amounts to from one-third to two-thirds of the manure recovered from the animal. Most of this loss occurs within the first three or four months, when fermentation, or "heating," is most active. To obtain the greatest value from the manure, it should be applied to the soil as soon as it is produced.

It is a common practice in the corn belt to pasture the corn stalks during the winter and often rather late in the spring after the frost is out of the ground. This tramping of stock sometimes puts the soil in bad condition for working. It becomes partially puddled and will be cloddy as a result. If tramped too late in the spring, the natural agencies of freezing and thawing, and wetting and drying, with the aid of ordinary tillage, fail to produce good tilth before the crop is planted. Whether the crop is corn or oats, it necessarily suffers, and if the season is dry, much damage may result. If the field is put in corn, a poor stand is likely to result, and if put in oats, the soil is so compact as to be unfavorable for their growth. Sometimes the soil is worked when too wet. This also produces a partial puddling which is unfavorable to physical, chemical, and biological processes. The bad effect will be greater if cropping has reduced the organic matter below the amount necessary to maintain good tilth.

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No.

76 Alfalfa on Illinois Soil. 1902 (5th edition, 1913)
*86 Climate of Illinois. 1903
*88 Soil Treatment for Wheat in Rotation, with Special Reference to Southern Illinois. 1903
*93 Soil Treatment for Peaty Swamp Lands, Including Reference to Sand and "Alkali" Soils. 1904 (See No. 157)
94 Nitrogen Bacteria and Legumes. 1904 (4th edition, 1912)
*99 Soil Treatment for the Lower Illinois Glaciation. 1905
*115 Soil Improvement for the Worn Hill Lands of Illinois. 1907
*123 The Fertility in Illinois Soils. 1908 (2d edition, 1911)
*125 Thirty Years of Crop Rotations on the Common Prairie Soil of Illinois. 1908
*145 Quantitative Relationships of Carbon, Phosphorus, and Nitrogen in Soils. 1910 (2d edition, 1912)
157 Peaty Swamp Lands; Sand and "Alkali" Soils. 1912
177 Radium as a Fertilizer. 1915
181 Soil Moisture and Tillage for Corn. 1915
182 Potassium from the Soil. 1915
190 Soil Bacteria and Phosphates. 1916
193 Summary of Illinois Soil Investigations. 1916
194 A New Limestone Tester. 1917
207 Washing of Soils and Methods of Prevention. 1918
208 Climate of Illinois. 1918

CIRCULARS

*64 Investigations of Illinois Soils. 1903
*68 Methods of Maintaining the Productive Capacity of Illinois Soils. 1903 (2d edition, 1905)
*70 Infected Alfalfa Soil. 1903
*72 Present Status of Soil Investigation. 1903 (2d edition, 1904)
*82 The Physical Improvement of Soils. 1904 (3d edition, 1912)
86 Science and Sense in the Inoculation of Legumes. 1905 (2d edition, 1913)
*87 Factors in Crop Production; Special Reference to Permanent Agriculture in Illinois. 1905
*96 Soil Improvement for the Illinois Corn Belt. 1905 (2d edition, 1906)
*97 Soil Treatment for Wheat on the Poorer Lands of the Illinois Wheat Belt. 1905
*99 The "Gist" of Four Years' Soil Investigations in the Illinois Wheat Belt. 1905
*100 The "Gist" of Four Years' Soil Investigations in the Illinois Corn Belt. 1905
*105 The Duty of Chemistry to Agriculture. 1906 (2d edition, 1913)
*108 Illinois Soils in Relation to Systems of Permanent Agriculture. 1907
109 Improvement of Upland Timber Soils of Illinois. 1907
110 Ground Limestone for Acid Soils. 1907 (3d edition, 1912)
*116 Phosphorus and Humus in Relation to Illinois Soils. 1908
*119 Washing of Soils and Methods of Prevention. 1908 (2d edition, 1912)
*122 Seven Years' Soil Investigation in Southern Illinois. 1908
123 The Status of Soil Fertility Investigations. 1908
*124 Chemical Principles of Soil Fertility. 1908
127 Shall We Use Natural Rock Phosphate or Manufactured Acid Phosphate for the Permanent Improvement of Illinois Soils? 1909 (3d edition, 1912)
*129 The Use of Commercial Fertilizers. 1909
130 A Phosphate Problem for Illinois Land Owners. 1909
*141 Crop Rotation for Illinois Soils. 1910 (2d edition, 1913)
142 European Practice and American Theory Concerning Soil Fertility. 1910
145 The Story of a King and Queen. 1910
*149 Results of Scientific Soil Treatment; and Methods and Results of Ten Years' Soil Investigation in Illinois. 1911
150 Collecting and Testing Soil Samples. 1911 (2d edition, 1912)
155 Plant Food in Relation to Soil Fertility. 1912
*157 Soil Fertility: Illinois Conditions, Needs, and Future Prospects. 1912
165 Shall We Use "Complete" Commercial Fertilizers in the Corn Belt? 1912 (4th ed., 1913)
167 The Illinois System of Permanent Fertility. 1913
168 Bread from Stones. 1913
181 How Not to Treat Illinois Soils. 1915
185 A Limestone Tester. 1916
186 I. The Illinois System of Soil Fertility from the Standpoint of the Practical Farmer. II. Phosphates and Honesty. 1916
193 Why Illinois Produces only Half a Crop. 1917
197 Essentials in Larger Food Production. 1917
208 Ten Wheat Yields in Egypt.
223 Sources of Fertilizing Materials for Illinois Farms. 1918
229 Illinois Wheat Yields with Nature's Fertilizers. 1918

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1 Clay. 1911
2 Moultrie. 1911
3 Hardin. 1912
4 Sangamon. 1912
5 La Salle. 1913
6 Knox. 1913
7 McDonough. 1913
8 Bond. 1913
9 Lake. 1915
10 McLean. 1915
11 Pike. 1915
12 Winnebago. 1916
13 Kankakee. 1916
14 Tazewell. 1916
15 Edgar. 1917
16 DuPage. 1917
17 Kane. 1917
18 Champaign. 1918

*Out of print.

SIXTEEN YEARS' RESULTS WITH PHOSPHORUS ON THE UNIVERSITY OF ILLINOIS SOIL EXPERIMENT FIELD AT BLOOMINGTON, ON THE TYPICAL PRAIRIE LAND OF THE ILLINOIS CORN BELT

Year	Crops grown	Yield without phosphorus	Yield with phosphorus	Increase for phosphorus	Value of increase per acre
1902	Corn, bu.	37.0	41.7	4.7	$ 2.35
1903	Corn, bu.	60.3	73.0	12.7	6.35
1904	Oats, bu.	60.8	72.7	11.9	4.76
1905	Wheat, bu.	28.8	39.2	10.4	19.40
1906	Clover, tons	.58	1.65	1.07	10.70
1907	Corn, bu.	63.1	82.1	19.0	9.50
1908	Corn, bu.	35.3	47.5	12.2	6.10
1909	Oats, bu.	53.6	63.8	10.2	4.08
1910	Clover, tons	1.09	4.21	3.12	31.20
1911	Wheat, bu.	22.5	57.6	35.1	35.10
1912	Corn, bu.	47.9	74.5	26.6	13.30
1913	Corn, bu.	30.0	44.1	14.1	7.05
1914	Oats, bu.	40.6	45.0	4.4	1.76
1915	Soybeans, bu.	0.0	0.0	0.0	0.00
1916	Wheat, bu.	15.8	38.8	23.0	23.00
1917	Corn, bu.	19.2	44.0	24.8	12.40

Total value of increase in sixteen years.......................................$178.05
Total cost of phosphorus in sixteen years.......................................56.00

Net profit in sixteen years.......................................$122.05

After the first year the phosphorus began to more than pay its annual cost; and during the second five-year period the increase produced by the phosphorus was worth almost as much as the total crops produced on the land not receiving phosphorus. In later years the need of organic manures with phosphorus has become apparent. (See pages 21 to 26 for more complete details.)

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PEORIA COUNTY SOIL TYPES

CONTENTS

REVISED DESCRIPTIONS OF

PEORIA COUNTY SOIL TYPES

With Recommendations for

THEIR USE AND MANAGEMENT

By R. S. Smith and Herman Wascher[1]

MANY changes have taken place in the mapping and naming of soil types since the soil report for Peoria county was printed sixteen years ago. Some of the types as earlier mapped have been subdivided into two or more types; and a few, particularly those occupying the bottomlands, have been combined. Even where no subdividing or combining has taken place, new names have been substituted for the former names.

The original soil report for Peoria county, published in 1921, has gone out of print, but a supply of the original maps is still available. As the maps still have very definite value, this revised statement has been prepared to accompany the remaining copies.

To use the original map with a revised description of types, the relation between the names and classifications shown on the map and those in current use, must be made clear. This has been done by retaining in the text, as the major headings, the old names, and listing under them the names now applied to the various subdivisions or combinations. Where merely a change in name is involved, both the old name and the new name are given in the heading.

With these facts in mind, it is believed that any one who will read carefully the descriptions here given will be able to recognize in the field the finer divisions into which many of the old types are now classified even tho these areas are not distinguished on the map.

A productivity index number is another new feature appearing in the description of each soil type. The numbers used in this index run from 1 to 10, No. 1 indicating the inherently most productive soils, unlimed and unfertilized, for growing the major crops common to the region, and No. 10, the inherently least productive.

UPLAND PRAIRIE SOILS

• Brown silt loam (26, 226, 526, 926, 1126)

Now subdivided into:

Tama silt loam (36)
Muscatine silt loam (41)
Grundy silt loam (43)
Saybrook silt loam (145)
LaRose silt loam (60)
Proctor silt loam (148)
Brenton silt loam (149)
Dodgeville silt loam (40)

Tama silt loam (36) is a dark-colored soil derived from loess, which occurs on rolling topography and has developed under grass vegetation. It is found most extensively in the western and northwestern parts of the county bordering

[1]R. S. Smith, Chief in Soil Physics and Soil Survey; Herman Wascher, Assistant Chief in Soil Survey.

the timber soils and adjacent to drainage ways not surrounded by timber soils. This type, together with Muscatine silt loam, includes the majority of the brown silt soils in Peoria county.

The surface is a 5- to 7-inch brown to light-brown silt loam, medium acid in reaction, and medium in organic matter and nitrogen. The subsurface is a 4- to 7-inch brownish-yellow silt loam, and the subsoil a 10- to 16-inch reddish-yellow silty clay loam. Surface drainage is rapid and underdrainage is good. Destructive erosion occurs following cultivation unless erosion control measures are adopted.

This soil, because of its depth and permeability, is well adapted to terracing. This is a medium-productive soil that responds well to proper treatment and management. Following an application of limestone, clover and alfalfa do well and good response follows the use of manure. The productive crop index is 3 to 4.

Muscatine silt loam (41) is a dark-colored, loess-derived soil developed on undulating topography under grass vegetation. It occurs in association with Tama silt loam.

The surface is a 7- to 10-inch brown silt loam, medium in acidity, and medium to high in organic matter and nitrogen. The subsurface is a 7- to 9-inch yellowish-brown silt loam, and the subsoil a 10- to 16-inch yellowish-brown silty clay loam. Natural drainage is good.

Tho harmful erosion may occur following cultivation, it may be satisfactorily controlled in most cases by good farming methods, thus usually eliminating the need for mechanical controls such as check dams and terraces. This is a productive soil and needs only good farming and proper treatment to produce good crops. The productive crop index is 2. Results from the Kewanee experiment field may be taken as a guide in the treatment of this soil (see Bulletin 425).

Grundy silt loam (43) is a dark-colored, loess-derived soil developed on nearly level topography under grass vegetation. It is not an extensive type, occurring principally in the southwestern and northwestern parts of the county. It commonly occurs between the areas of Grundy clay loam and Muscatine silt loam.

The surface is an 8- to 10-inch dark-brown silt to clayey silt loam, high in organic matter and nitrogen, and neutral to only slightly acid in reaction. The subsurface is a 7- to 9-inch dark drabbish-brown clayey silt loam, and the subsoil a 12- to 16-inch brownish-drab clay loam. Surface drainage is fair and tile draw satisfactorily if an outlet with sufficient fall can be secured.

This is a highly productive soil adapted to the crops common to the region. The productive crop index is 1. No soil treatment is suggested other than the application of limestone if the need for it is indicated by the acidity test or by poor clover growth. Provision for regular additions of leguminous organic matter should be made.

Saybrook silt loam (145) is a dark-colored soil, derived from a thin loess blanket on friable, calcareous till and developed on undulating to rolling topography. It does not occur extensively in Peoria county, being found only on the Wisconsin glaciation to the southwest of Lawn Ridge. It makes up a portion of the area designated on the map as 926 and 1126.

The surface is a 4- to 8-inch brown silt loam, varying according to the effect

of erosion. It is fairly high in organic matter and nitrogen and slightly to medium acid in reaction. The subsurface is a 6- to 8-inch yellowish-brown silt loam, and the subsoil a 10- to 16-inch yellowish-brown silty clay loam with a scattering of pebbles. Surface drainage and underdrainage are both good.

Serious erosion occurs following cultivation, particularly on the more rolling portions. Good erosion control, such as proper cropping practices and contour tillage should be followed on all the eroding portions of this type, supplemented in places by terraces. Crop yields are good for the most part but may be satisfactorily increased by the limestone-legume-manure treatment. This is one of the productive corn-belt soils which is being seriously injured by erosion. Erosion-control measures should be promptly adopted before further permanent harm has been done. The productive crop index is 3.

LaRose silt loam (60) is a medium dark-colored soil, derived from a thin loess blanket on calcareous, friable till. It has developed under grass vegetation on rolling to strongly rolling topography. It occurs only on the Wisconsin glaciation in association with Saybrook silt loam. It is probably somewhat more extensive in occurrence than Saybrook.

The surface is a 3- to 6-inch brown to light-brown silt loam, medium in organic matter and nitrogen, and medium acid in reaction. The subsurface is a 3- to 7-inch dull reddish-brown silt loam, and the subsoil a 10- to 16-inch brownish-yellow silty clay loam. Surface drainage is excellent to excessive and underdrainage is good.

Destructive erosion follows cultivation unless protective measures are used. For the most part terracing is not advisable because of the thinness of the loess cover. Contour farming and proper cropping practices are effective in controlling erosion on this soil. Following an application of limestone this type makes good alfalfa land. Some of the steeper slopes on which this soil occurs have already been so seriously injured by erosion that they should be seeded down to permanent grass in order to control erosion and allow the soil to gradually recover. The productive crop index is 5 to 7.

Proctor silt loam (148) is a glacial-outwash-derived soil developed under conditions of good drainage, with grass as the natural vegetation. It is not an extensive type, being found only in the outwash area north of Princeville.

The surface is a 6- to 8-inch brown to light-brown silt loam, medium in organic matter and nitrogen and medium acid. The subsurface is a brownish-yellow silt loam, and the subsoil a 10- to 16-inch brownish-yellow silty clay loam.

It is a medium productive soil that builds up quickly under the limestone-legume-manure treatment, but which likewise declines quickly in producing capacity unless well farmed. Alfalfa does well following proper soil treatment. Harmful sheet erosion may occur following cultivation but can be satisfactorily controlled by the proper use of cover crops. The productive crop index is 3. A few small areas may have coarse outwash material within 30 inches of the surface. These spots will tend to be drouthy and their crop index is about 6.

Brenton silt loam (149) is a dark-colored soil derived from a thin loess cover on glacial outwash and developed under grass vegetation on flat to undulating topography. It occurs north of Princeville in association with Proctor silt loam.

The surface is an 8- to 10-inch dark-brown silt loam, high in organic matt and nitrogen and neutral to slightly acid in reaction. The subsurface is a 6- 8-inch drabbish-brown silt loam, and the subsoil a 10- to 16-inch yellowish-dr silty clay loam. Surface drainage and underdrainage are fair to good and t draw satisfactorily if an outlet with sufficient fall can be secured.

This is a good soil and responds well to good farming, including the use limestone and legumes. The productive crop index is 2.

Dodgeville silt loam (40) is a dark-colored soil derived from a thin loess, glacial till, or outwash cover on limestone bedrock. It is of very minor importance but is known to occur about three miles northeast of Princeville. A small limestone quarry has been in operation in this area for several years. The thinner portions of this type are drouthy and consequently should be devoted to early maturing crops; otherwise it may be treated the same as surrounding types, tho probably its best use is for meadow and pasture.

• Black clay loam (20, 520, 1120, 1520)

Now subdivided into:

Grundy clay loam (65)
Drummer clay loam (152)
Hersman clay loam, terrace (195)

Grundy clay loam (65) is a loess-derived, dark-colored soil developed on broad flats or depressional areas, under heavy slough grass or luxuriant prairie grass vegetation.

The surface is an 8- to 10-inch black clay loam, high in organic matter and nitrogen and neutral in reaction, with an occasional small alkali spot. The subsurface is a 6- to 8-inch black to drabbish-black clay loam, and the subsoil a 10- to 18-inch yellowish-drab clay loam. Surface drainage is poor but natural, underdrainage is fair and tile draw satisfactorily if an outlet with sufficient fall can be secured.

When sufficiently well drained, this is a productive soil, especially for corn, tho some care must be used in cultivating it, in order to avoid the development of a bad physical condition. The productive crop index is 1. Many small areas of clay loam occur which are not shown on the map because of their small size. Most of these areas belong to this type.

Drummer clay loam (152) is similar to Grundy clay loam except that it is derived from glacial wash and frequently contains pebbles. It occurs in association with Proctor, Brenton and Saybrook silt loams. The productive crop index is 1.

Results from the Hartsburg experiment field may be taken as a guide in the treatment of both Grundy and Drummer clay loams (see Bulletin 425).

Hersman clay loam, terrace (195) is similar to Grundy clay loam except that it occurs on river terraces and is underlain by sand and gravel. It is shown on the map by the number 1520.

This soil is productive and ordinarily needs no treatment other than the regular addition of organic matter. Its productive crop index is 1.

• Brown-gray silt loam on tight clay (28, 528, 928)

Now subdivided into:

Denny silt loam (45)
Osceola silt loam (58)

Denny silt loam (45) is a loess-derived soil that has developed in small depressions under weedy prairie or scattered, brushy timber vegetation. It sometimes occurs between Muscatine silt loam and light-colored timber soil, altho its usual occurrence is in poorly drained spots within the Muscatine areas.

The surface is a 7- to 9-inch grayish-brown silt loam, medium in organic matter and nitrogen, and acid in reaction. The subsurface is a 5- to 7-inch brownish-gray silt loam and the subsoil a 16- to 22-inch drabbish-gray plastic clay loam. Surface drainage is poor and underdrainage is slow.

Altho some crops may make fair yields, a heavy application of limestone and the growing of legumes are necessary to secure satisfactory returns. Manure gives good returns provided drainage has been established. The crop index is 7.

Osceola silt loam (58) is an outwash-derived soil that has developed on depressional to gently undulating topography where the Illinoian gumbotil or other impervious substratum has caused a continued high water table. It occurs in the outwash area north of Princeville.

The surface is a 6- to 8-inch grayish-brown silt loam, medium to low in organic matter and nitrogen. The subsurface is a 5- to 8-inch slaty-gray silt loam and the subsoil is a 6- to 14-inch drabbish-gray plastic clay loam. Surface drainage is fair to poor and underdrainage is slow.

A heavy initial application of limestone, together with the growing of legumes, or the frequent application of manure, is necessary to bring this soil to a satisfactory productive level. The productive crop index is 6 to 8.

UPLAND TIMBER SOILS

• Yellow-gray silt loam (34, 234, 534, 934, 1134)

Now subdivided into:

Berwick silt loam (17)
Clinton silt loam (18)
Miami silt loam (24)

Berwick silt loam (17) is a loess-derived, light-colored soil that has developed on nearly level topography under forest vegetation.

The surface is a 6- to 8-inch yellowish-gray silt loam, low in organic matter and nitrogen, and acid in reaction. The subsurface is a 6- to 8-inch pale yellowish-gray silt loam, and the subsoil a 12- to 18-inch mixed pale-yellow and gray, plastic clay loam. Natural drainage is slow.

This soil should be kept in timber. However, if already cleared, an application of limestone and regular applications of manure, or the growing and plowing under of sweet clover, will raise the productive level. This soil, however, does not respond so well to good treatment as does Clinton silt loam with which it is associated. The productive crop index is 6 to 7, with a few small very poorly drained spots probably rating as low as 8.

Clinton silt loam (18) is a loess-derived soil developed under forest vegetation on undulating to rolling topography.

The surface is a 4- to 7-inch grayish-yellow silt loam, low in organic matter and nitrogen, and acid in reaction. The subsurface is a 4- to 7-inch grayish yellow silt loam, and the subsoil a 12- to 20-inch drabbish-yellow silty clay loam with gray mottling. Surface drainage and natural underdrainage are both good.

Serious erosion occurs following cultivation unless protective measures are used, including contour farming, maintenance of a vegetative cover, and in some cases, terracing. This soil has a low productive level when farmed without treatment, but it has the capacity to respond to limestone and legumes and to manure. It makes good permanent pasture land and when limed the carrying capacity is greatly increased. The productive crop index is 5.

Miami silt loam (24) is a light-colored soil, derived from a thin loess blanket on friable, calcareous glacial till. It has developed on rolling topography under a forest vegetation. It occurs only within the 934 and 1134 areas, as shown on the map, for the most part just to the south of Dunlap.

The surface is a 4- to 7-inch yellowish-gray silt loam, low in organic matter and nitrogen, and acid in reaction. The subsurface is a 5- to 8-inch grayish-yellow silt loam, and the subsoil is a 10- to 16-inch grayish-yellow silty clay loam. Surface drainage and underdrainage are both good.

Erosion is serious following cultivation unless protective measures are used. Terracing is generally not advisable because of the thinness of the loess cover. Following an application of limestone this type makes good pasture land. The productive crop index is 5.

• Yellow silt loam (35, 235, 535, 935, 1135)

Now subdivided into:

Hickory gravelly loam, eroded (8)
Fayette silt loam (19)
Hennepin gravelly loam, eroded (25)
Strawn silt loam (224)

Hickory gravelly loam, eroded (8) is made up of the steep stream bluffs and adjacent gullied land in the southern, central, western and northwestern parts of the county. It is normally found only on slopes that exceed 15 to 20 percent and from which the loess cover has been generally removed.

In a virgin forest area it usually has a 3- to 5-inch brownish-yellow surface, a 2- to 4-inch yellow subsurface and a 10- to 15-inch reddish-yellow, gravelly subsoil. Destructive erosion follows the removal of the natural forest cover so that any or all of the above-mentioned soil layers may be absent, exposing in the latter case, the plastic, leached, gravelly drift.

Since bluegrass usually makes only a fair growth, this land should be kept in permanent timber. The productive crop index is 10.

Fayette silt loam (19) is a light-colored soil derived from loess, developed on strongly rolling topography or on slopes of 7 to 15 percent and under forest vegetation. It is found most extensively in the southern part of the county along the bluffs of the Illinois river altho much of the 535 area shown on the map in the central part will also classify as this type.

In a virgin forest area the surface is a 3- to 5-inch, brownish-yellow silt loam, low in organic matter and nitrogen, and medium acid in reaction. The subsurface is a 4- to 6-inch, yellow silt loam. The subsoil is 12 to 20 inches thick and is a reddish-yellow silty clay loam.

Destructive erosion follows cultivation unless the soil is continuously protected by a vegetative cover. In some areas this soil lends itself to terracing because of the thickness of the loess; however, many of the slopes are too steep for successful terracing. Much of this soil type is too steep for cultivation and should be kept in grass or timber. The less steep slopes may be put in a cultivated crop at intervals but should be returned to grass following a grain crop. The productive crop index is 7 to 8.

Hennepin gravelly loam, eroded (25) is made up of the steep stream bluffs and adjacent gullied land of the Wisconsin till region in the northeastern part of the county. It is normally found only on slopes that exceed 15 to 20 percent and from which the loess cover has been mostly removed.

In a virgin forest area it usually has a 3- to 5-inch brownish-yellow surface, a 2- to 4-inch yellow subsurface, and a 6- to 12-inch reddish-yellow, gravelly subsoil. Destructive erosion follows the removal of the natural forest cover so that part or all of the above-mentioned soil layers are often absent. The underlying calcareous, gravelly till becomes exposed when all of the soil layers are removed.

Bluegrass commonly makes a satisfactory growth if established before erosion removes the surface layers; however, the type is best kept permanently in timber. The productive crop index is 10.

Strawn silt loam (224) is a light-colored soil derived from thin loess on calcareous till. It has developed under forest vegetation on strongly rolling topography, or on slopes of 7 to 15 percent. It is found only in the Wisconsin till region of the eastern and northeastern parts of the county.

In undisturbed forest areas the surface is a 3- to 5-inch, grayish- to brownish-yellow silt loam. The subsurface is a 4- to 7-inch yellow silt loam and the subsoil is a 12- to 16-inch reddish-yellow silty clay loam, often with some pebbles in the lower part of this horizon.

This soil is subject to destructive erosion when farmed, unless effective erosion-control measures, including contour tillage, strip cropping, frequent use of grass, and terracing on the less steep slopes, are practiced. In any case, if this soil is used for tilled crops, soil treatment must be applied to help get a vigorous vegetative growth. The best use for Strawn silt loam is pasture and meadow on the more moderate slopes and timber on the steeper slopes.

TERRACE SOILS

• Brown sandy loam (1560)

Now Sumner sandy loam, terrace (87)

Sumner sandy loam, terrace (87) is a medium dark-colored terrace soil developed on undulating to gently rolling topography. The knolls and ridges are light brown and very sandy. Drainage is good for the most part. Even tho this soil has developed under prairie vegetation the organic-matter and nitrogen con-

tents are medium to low owing to the coarse texture and ready permeability of the soil material.

This soil shows little horizon development. The surface is a yellowish-brown or light-brown sandy loam. With increasing depth the color gradually changes to reddish yellow and the texture becomes somewhat coarser.

While it is not commonly thought of as a drouthy soil its resistance to drouth is only fair. Crop residues and manure should be turned under at frequent intervals. Some limestone is necessary in order to obtain good results with clover. This type is also low in phosphorus. The productive crop index is 7.

• Brown silt loam (26, 1526)

Now Littleton silt loam, terrace (81)

Littleton silt loam, terrace (81) is a dark-colored terrace type, corresponding to the upland type Muscatine silt loam, No. 41, and requires the same management and treatment as does Muscatine. The productive crop index is 3.

• Brown fine sandy loam (1571)

Now Worthen fine sandy loam, bluff wash (37)

Worthen fine sandy loam, bluff wash (37) is found mainly at the base of the Illinois river bluffs.

It is variable in texture, color, and depth of horizons since these features depend on the rate of deposition and the kind of material deposited.

The silty and fine sandy portions are very productive, while some spots covered by recent gravel wash may be practically barren. When the adjacent bluff land is cleared of trees and brush, short, sharp gullies quickly form and the underlying gravelly glacial till is washed out and deposited on the fine sandy loam in the form of small gravel fans. The productive crop index is variable for the reason stated above.

• Dune sand (81, 1581)

At the present time there is no official type name nor number under the later system of nomenclature for this soil.

Dune sand is a light-brown loamy sand to sand, low in organic matter, nitrogen, and phosphorus, and acid in reaction. Underdrainage is very rapid due to coarse texture thruout the deep profile as well as to lack of organic matter and no subsoil development.

The topography of this soil is rolling for the most part, the type occupying the tops of knolls and ridges in close association with the lighter portions of Sumner sandy loam. These knolls and ridges were caused by the wind, and the loose sand that forms them will continue to be blown about unless a vegetative cover is used to prevent movement. Small grains and legumes, or trees, are the best crops for this purpose. The productive crop index is 9.

• Brown silt loam on gravel (1526.4)

Now O'Neill silt loam, terrace (79)

O'Neill silt loam, terrace (79) is a medium dark-colored soil developed on undulating to gently rolling topography.

The surface is a 5- to 8-inch brown to light-brown silt loam, medium in organic matter and nitrogen, and acid in reaction. In places there is a high percentage of coarse sand present. The subsurface is a 6- to 8-inch reddish-brown sandy silt loam and the subsoil a reddish-yellow silty clay loam with sand or pebbles present. Surface drainage is good and underdrainage excessive.

This soil is drouthy and attempts at permanent improvement are usually not very successful. Winter crops are better adapted to this soil than summer crops. The productive crop index is 7. The underlying material is a common source of commercial sand and gravel.

• Yellow-gray silt loam over gravel (1536)

Now Camden silt loam, terrace (134)

Camden silt loam, terrace, (134) is a terrace type similar in profile characteristics to Clinton silt loam, No. 18. The productive crop index is 5. Tho sand and gravel occur at varying depths they always occur below 30 inches and usually are not loose and incoherent until below 35 or 40 inches. Treatment should be the same as for Clinton silt loam.

• Yellow-gray sandy loam (1564)

Now Potomac sandy loam, terrace (135)

Potomac sandy loam, terrace (135) is similar to Camden silt loam, No. 134, described above, except that the surface and subsoil are coarser textured and more permeable. It is a light-colored or timbered phase of Sumner sandy loam, No. 87, and treatment should be about the same on the two types. The productive crop index is 8.

• Yellow-gray sandy loam on gravel (1564.4)

Now Ellison sandy loam, terrace (209)

Ellison sandy loam, terrace (209) is a sandy terrace soil developed under timber vegetation. It is a light-colored phase of O'Neill sandy loam, No. 79, described above, and treatment should be similar. The productive crop index is 9.

• Brown sandy loam on gravel (1560.4)

Now O'Neill sandy loam, terrace (63)

O'Neill sandy loam, terrace (63) is similar to O'Neill silt loam, No. 79, described above, except that the texture is coarser, even more or less gravelly, and the organic matter content consequently somewhat lower. Treatment should be similar to that suggested for O'Neill silt loam. The productive crop index is 8.

• Brown-gray silt loam on tight clay (1528)

Now Brooklyn silt loam, terrace (136)

Brooklyn silt loam, terrace (136) occurs as small, poorly-drained spots on the terrace. Except that terrace sand and gravel underlies this type at varying depths, it is similar to Osceola silt loam, No. 58, and treatment should be the same as that suggested for Osceola.

SWAMP AND BOTTOMLAND SOILS
(Old and Late)

• Deep brown silt loam (1326, 1426)
Now Huntsville silt loam, bottom (77)

Huntsville silt loam, bottom (77) is a silty bottomland type derived from sediment carried out of deep loess country. In the small stream bottoms it is often slightly sandy while in the Illinois river bottom it grades into heavy clay loam.

Ordinarily no soil horizons can be defined because the material is of too recent deposition. Organic-matter content is fairly high, and the reaction is usually neutral. Because of frequent deposition of new material little need be done beyond good cultivation in keeping up the productiveness of this soil. The productive crop index is 2 to 5, depending upon frequency of overflow.

• Mixed loam (1354, 1454)
Now Huntsville loam, bottom (73)

Huntsville loam, bottom (73) occupies all of the creek bottoms in the southern, central, and eastern parts of the county. It varies locally from sand of small sand bars to clay of small oxbows, but is principally a sandy brown silt loam, fairly high in organic matter and nitrogen, and neutral to very slightly acid in reaction. It is subject to frequent overflow unless protected by levee. Therefore, the cropping system is usually limited. The productive crop index is 3 to 5 depending, in part, on the frequency and harmfulness of overflow.

• Deep peat (1301)
Now Deep peat (97)

Deep peat (97). Peat areas in Illinois have not been differentiated to date except as to thickness of deposit, and this changes rapidly following cultivation. Two small areas are shown on the map in the creek bottom two miles north of Kickapoo. The material in these areas is well decomposed and probably would not classify as true peat at this time. Following adequate drainage good crops are produced when potash fertilizer is used. This soil is not adapted to the small grains as they tend to lodge, but it produces good corn when fertilized as above indicated.

• Drab clay (1415)
Now Sawmill clay loam, bottom (107)

Sawmill clay loam, bottom (107) is a dark-colored soil, relatively high in organic matter and nitrogen, and neutral in reaction. The surface is a black or drabbish-black clay loam while the subsurface and subsoil are more grayish and silty. When protected by levee and drained this makes excellent corn land. The productive crop index is 2 to 6. The lower rating applies where the soil is not protected by levee.

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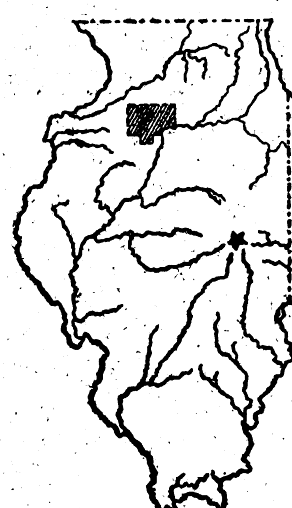
UNIVERSITY OF ILLINOIS

Agricultural Experiment Station

SOIL REPORT No. 20

BUREAU COUNTY SOILS

By J. G. MOSIER, S. V. HOLT, E. VAN ALSTINE
AND F. W. GARRETT
PREPARED FOR PUBLICATION BY L. H. SMITH



URBANA, ILLINOIS, DECEMBER, 1921

IN RECOGNITION

The Soil Survey of Illinois was organized under the supervision of the late Dr. Cyril G. Hopkins. The work progressed for eighteen years under his guidance, and the first eighteen soil reports bear his name as senior author. On October 6, 1919, Dr. Hopkins died in a foreign land in the service of the American Red Cross. It is the purpose to carry on to completion this great work of the Illinois Soil Survey in the spirit, and along the same general plan and lines of procedure, in which it was begun.

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1921

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INTRODUCTORY NOTE

It is a matter of common observation that soils vary tremendously in their productive power, depending upon their physical condition, their chemical composition, and their biological activities. For any comprehensive plan of soil improvement looking toward the permanent maintenance of our agricultural lands, a definite knowledge of the various existing kinds or types of soil is a first essential. It is the purpose of a soil survey to classify the various kinds of soil of a given area in such a manner as to permit definite characterization for description and for mapping. With the information that such a survey affords, every farmer or land owner of the surveyed area has at hand the basis for a rational system of improvement of his land. At the same time the Experiment Station is furnished an inventory of the soils of the state, upon which intelligently to base plans for those fundamental investigations so necessary for solving the problems of practical soil improvement.

This county soil report is one of a series reporting the results of the soil survey which, when completed, will cover the state of Illinois. Each county report is intended to be as nearly complete in itself as it is practicable to make it, even at the expense of some repetition. There is presented in the form of an Appendix a general discussion of the important principles of soil fertility, in order to help the farmer and land owner to understand the significance of the data furnished by the soil survey and to make intelligent application of the same in the maintenance and improvement of the land. In many cases it will be of advantage to study the Appendix in advance of the soil report proper.

Data from experiment fields representing the more extensive types of soil, and furnishing valuable information regarding effective practices in soil management, are embodied in form of a Supplement. This Supplement should be referred to in connection with the descriptions of the respective soil types found in the body of the report.

CONTENTS OF SOIL REPORT No. 20

BUREAU COUNTY SOILS

APPENDIX

SUPPLEMENT

BUREAU COUNTY SOILS

By J. G. MOSIER, S. V. HOLT, E. VAN ALSTINE, AND F. W. GARRETT
PREPARED FOR PUBLICATION BY L. H. SMITH[1]

FORMATION

Bureau county is located in the west central-northern part of Illinois, the northwest corner being about twenty-six miles from the Mississippi river. There is much variation in the soils, due to the many agencies that have been instrumental in their formation. The northwestern part of the county is in the sand and gravel terrace formed by the Rock and Green rivers. An extension of this terrace to the southeast that reaches to Bureau creek without doubt indicates a former connection between the Rock and Illinois rivers.

During the Glacial period snow and ice accumulated in the region of Labrador and to the west of Hudson Bay to such an amount that the mass pushed outward from these centers, especially southward, until a point was reached where it melted as rapidly as it advanced. In moving across the country from the far north the ice gathered up all sorts and sizes of material, including clay, silt, sand, gravel, and boulders. Some of these materials were carried for hundreds of miles and rubbed against surface rocks and against each other, producing large quantities of rock flour. When, thru the melting of the ice, the limit of advance was reached, the material carried by the glacier was deposited, accumulating in a broad undulating ridge or moraine. When the ice melted more rapidly than the glacier advanced, the terminus of the glacier would recede and the material would be deposited somewhat irregularly over the area previously covered.

THE GLACIATIONS OF BUREAU COUNTY

During the Glacial period there were six distinct and separate glacial advances as follows, in order of their occurrence:

(1) The Nebraskan, which did not touch Illinois. (2) The Kansan, which covered parts of Hancock and Adams counties. The Weymouth soil was developed from the surface of the Kansan glacial material. (3) The Illinoisan, which covered all of the state except the northwest corner (practically all of Jo Daviess county), the southern part of Calhoun county, and the seven southernmost counties. The Sangamon soil was formed from the surface of the Illinoisan drift. (4) The Iowan, which covered a part of northern Illinois. The area covered by this advance is difficult to determine because of the later glaciations. At about the close of the Iowan glacial advance, loess or wind deposits were made. The surface of this material was formed into the Peorian soil, which was buried by the early Wisconsin glaciation. (5) The early Wisconsin glaciation, which covered the northeastern part of the state as far west as Peoria and

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south to Shelbyville. (6) The late Wisconsin glaciation, which extended to the west line of McHenry county and south to the town of Milford in Iroquois county.

Only three of these glacial advances covered all or part of Bureau county, burying the old soils and producing new ones. The first of these was the Illinoisan glacier, which probably covered the entire county. Subsequent glaciers covered most of this deposit leaving the Illinoisan drift exposed only in the southwestern part of the county, including Towns 15 North, Ranges 6 and 7 East, and the western tier of sections in Town 14 North, Range 8 East. A system of moraines extends across the first two townships and marks the northern limit of the exposed Illinoisan drift. The Illinoisan glacier was followed by the Iowan, which covered most of the county north of Town 15 North. Nearly all of the Iowan drift, however, has been covered by a subsequent glacier. The map, page 3, shows the approximate area of the Iowan glaciation now exposed.

The latest glacial advance that reached this county was the early Wisconsin, which covered the eastern two-thirds of the county and built up a very extensive moraine known as the Bloomington morainic system. This forms the ridge upon which Providence and Milo are located. This moraine extends to the northward and forms the divide between the Rock and the Illinois rivers. In the northeast part of the county the Bloomington system is formed by two ridges, an outer or western, and an inner or eastern ridge, the latter of which passes out at the northeast corner of the county. The Illinoisan moraine in the southwestern part of the county extends southeastward and merges with the Bloomington moraine. A fourth glaciation, the late Wisconsin, did not reach the county, but the water from the melting ice and the sediment which it carried down the Rock river undoubtedly played an important part in the formation of new soils and the modification of the old ones in the northwestern part of the county.

The material transported by the glacier varied with the character of the rocks over which it passed. Granites, limestones, sandstones, shales, etc., were encountered by the glacier, and both large and small masses of these were torn from their resting places by the enormous denuding power of the ice, ground up more or less together, and moved along with the glacier and later deposited as the ice melted. A pressure of forty pounds per square inch is exerted by a mass of ice one hundred feet thick, and these ice sheets were hundreds and possibly thousands of feet in thickness. The ice, together with the boulders and pebbles carried in it, thus became a powerful agent for grinding and wearing away the surface over which it passed. Ridges and hills were rubbed down, valleys were filled with the debris, and the surface features were changed entirely. When the ice melted, this material was deposited, and it is known as boulder clay, till, glacial drift, or simply drift.

The thickness of this deposit in Bureau county varies from a few feet to about 600 feet, the greatest depth being in the old valley thru which the Rock river is supposed to have reached the Illinois. The average depth of drift in this county is at least 200 feet, and may possibly be as much as 300 feet. In many places strata of sand occur in the glacial drift. Old soils and fragments of trees are frequently encountered in the drift at depths as great as 130 feet. These soils represent interglacial periods when the glaciers receded, during

which ordinary conditions prevailed. It is believed that the drift in this county is deeper than any other in the state. The till, especially at a few feet in depth, is of a bluish color, and is commonly designated as blue clay.

PHYSIOGRAPHY AND DRAINAGE

Bureau county varies in topography from hilly to flat. These variations are due: first, to deposition of material transported by streams; second, to irregular deposition of material carried by glaciers; third, to material piled up by the wind, giving a dune topography; and fourth, to erosion by streams. The material deposited by streams gives rise to flat or very slightly undulating flood plains or older terrace deposits. These are found principally along the Illinois river, Bureau creek, and the Green river. In some cases the terrace deposits are slightly rolling, owing probably to the deposition of bars in broad, rather strong, currents of water.

The peculiar topography of glacial areas is due to the fact that the drift material was not uniformly distributed thruout the mass of ice, and when the ice melted it left the material in irregular heaps. The morainic areas are characterized by a peculiar billowy topography produced by the irregular piling up of material at the end of the glacier and by the covering up of ice masses in the moraines which, when they melted, produced depressions. The intermorainic areas vary in topography to a slight extent, giving a gently rolling character to the land.

MAP SHOWING THE DRAINAGE BASINS OF BUREAU COUNTY WITH MORAINAL, TERRACE, BOTTOM-LAND, AND SWAMP AREAS

The dune topography occurs in the northwestern part of the county within the terrace area and on the adjacent uplands. The terrace, during the time of the melting glacier, was largely covered by water and received deposits of gravel, sand, and finer material. Much of the sand and silt was reworked by the wind and piled up into dunes. The erosion topography occurs along nearly all streams outside of the terrace area. The east side of the Bloomington moraine in the southern part of the county is rather badly eroded by a large number of small streams.

There are three rather distinct drainage areas in the county: one in the southwestern part (the Spoon river basin, which is a part of the Illinois basin); one in the northwestern part (the Green river basin, which is really a part of the Rock river); and one in the eastern and southeastern part, which drains either directly into the Illinois river or into Bureau creek, which flows into the Illinois. Approximately two-thirds of the county is in this last drainage area. The county originally contained a large area of swamp land that has recently been drained into the Green river by means of dredge ditches.

The altitudes of some places in Bureau county are as follows: Arlington, 762 feet; Buda, 767; Bureau Junction, 480; Casbeer, 746; Depue, 472; Green Oak, 725; Ladd, 653; La Moille, 803; Malden, 705; Manlius, 795; Milo, 885; Mineral, 636; Neponset, 829; New Bedford, 650; Ohio, 917; Princeton, 718; Providence, 975; Spring Valley, 465; Sheffield, 671; Tiskilwa, 519; Van Orin, 807; Walnut, 714; Wyanet, 656; Yorktown, 638; Zearing, 761.

The highest point recorded in Bureau county occurs on the Bloomington moraine northeast of Providence, where the land rises to 987 feet above sea level. About a mile north of the village of Ohio the same moraine attains a height of approximately 940 feet. The lowest point in the county is 431 feet, giving a range of 556 feet in altitude. The Bloomington moraine, representing the outer edge of the Wisconsin till sheet, has a number of points over 900 feet in height. To the east of this moraine the drop is somewhat gradual until a height of approximately 750 feet is reached, while to the west of this moraine the drop reaches 650 feet. This gives about 100 feet more of relief to the west than to the east. One decided break occurs in the moraine, thru which the canal passes at the present time and which at one time formed the valley thru which the Rock river probably flowed to the Illinois.

SOIL MATERIAL AND SOIL TYPES

Altho the county has been largely covered by glaciers, the glacial drift does not constitute any large part of the material from which the soils have been derived directly. The county has been covered by a stratum of wind-blown or loessial material that varies from four to twelve feet or more in thickness. This constitutes the material from which the soil has been formed. In the terrace region in the northwest part of the county, the streams have mixed this to a greater or less extent with material, often coarser, that has been carried and deposited by them.

In general, the loessial material is deeper on the Illinoisan and Iowan drift, because, being older, there has been more time for deposition. It is also deeper on the flat areas than on the rolling ones because of the fact that erosion has removed much from the rolling land, in some cases leaving the glacial drift ex-

TABLE 1.—SOIL TYPES OF BUREAU COUNTY, ILLINOIS

Soil type No.	Name of type	Area in square miles	Area in acres	Percent of total area
	(a) Upland Prairie Soils (200, 500, 700, 900, 1100)			
-26	Brown silt loam	461.56	295,398	53.41
-60	Brown sandy loam	20.21	12,934	2.34
-20	Black clay loam	1.53	979	.18
-25	Black silt loam	7.52	4,813	.87
-28	Brown-gray silt loam on tight clay	.13	83	.01
-81	Dune sand	.25	160	.02
-90	Gravelly loam	1.57	1,005	.18
		492.77	315,372	57.01
	(b) Upland Timber Soils (200, 500, 700, 900, 1100)			
-34	Yellow-gray silt loam	78.37	50,157	9.07
-35	Yellow silt loam	56.88	36,403	6.58
-64	Yellow-gray sandy loam	.21	134	.02
		135.46	86,694	15.67
	(c) Terrace Soils (1500)			
1527	Brown silt loam over gravel	59.65	38,176	6.90
1560	Brown sandy loam	27.94	17,882	3.24
1561	Black sandy loam	13.48	8,627	1.56
1581	Dune sand	10.79	6,906	1.25
1550	Black mixed loam	3.93	2,515	.46
1525	Black silt loam	4.92	3,149	.57
1564	Yellow-gray sandy loam	4.96	3,174	.58
1571	Brown fine sandy loam	1.82	1,165	.21
1520	Black clay loam	.66	422	.08
1568	Brown-gray sandy loam on tight clay	2.44	1,562	.28
1536	Yellow-gray silt loam over gravel	3.31	2,118	.38
1564.4	Yellow-gray sandy loam on gravel	.33	211	.04
1560.4	Brown sandy loam on gravel	.12	77	.01
1528	Brown-gray silt loam on tight clay	.17	109	.02
1590	Gravelly loam	.17	109	.02
		134.69	86,202	15.60
	(d) Swamp and Bottom-Land Soils (1300, 1400)			
1354 / 1454	Mixed loam	39.81	25,478	4.61
1401	Deep peat	10.00	6,400	1.16
1402	Medium peat on clay	3.22	2,061	.37
1410	Peaty loam	17.07	10,925	1.98
1420	Black clay loam	.25	160	.02
1425	Black silt loam	6.82	4,365	.79
1426	Deep brown silt loam	12.90	8,256	1.49
1450	Black mixed loam	.66	422	.08
1461	Black sandy loam	8.76	5,606	1.01
		99.49	63,673	11.51
	Water	1.82	1,165	.21
	Total area of county	864.23	553,106	100.00

posed. The various agencies that have been at work in the formation and transportation of soil material necessarily give the soils of the county a varied character. In addition to the transporting agencies, the accumulation of organic matter has gone on in the swamps and, to a slightly less extent, upon the uplands, and this together with the mineral material, has added to the complexity of the soils.

Many of the smaller streams originally did not have distinct channels, but flowed sluggishly in broad shallow valleys, or "sloughs." In some cases the streams flowing into these from the upland were sufficiently swift to transport fine gravel and coarse sand, while in other cases nothing but the finer material was carried. This has given rise to soils that contain some gravel and sand in areas where normally only fine material would be found.

The soils of Bureau county are divided into the following classes:

(a) Upland Prairie Soils.—These are rich in organic matter. This land was originally covered with prairie grasses, the partly decayed roots of which have been the source of the organic matter. The flat prairie land contains a higher amount of this constituent than the undulating or rolling prairie, because the grasses and roots grew more luxuriantly there, and the higher moisture content retarded their decay.

The upland prairie soils include some areas of recent timber growth where certain kinds of trees have spread over the prairie, but this forestation has not been of sufficient duration to produce the characteristic timber soils. These areas, of greater or less width, are found along the border of most timber tracts, so that the timber actually extended a little farther than the soil type indicates.

(b) Upland Timber Soils.—These include a large part of the upland that was formerly covered with forests. These soils contain much less organic matter than the prairie soils, because the large roots of dead trees added but little, and the surface accumulations of leaves, twigs, and fallen trees were burned by forest fires or suffered almost complete decay. The timber lands are divided chiefly into two subclasses—the undulating and the hilly areas.

(c) Terrace Soils.—These include bench lands, or second bottom lands. They were formed by deposition from streams overloaded with coarse sediment during the melting of the glacier and subsequently. Finer deposits which were later made upon the coarse gravelly material now constitute the soil.

(d) Late Swamp and Bottom-Land Soils.—These include the present overflow lands, or flood plains of streams, and the very poorly drained lowlands, where peats and peaty loams have been formed.

Table 1 gives the area of each type of soil in Bureau county, and its percentage of the total area. The accompanying map shows the location and boundary of each type of soil, even when the type covers but a few acres.

INVOICE OF PLANT FOOD IN BUREAU COUNTY SOILS

SOIL ANALYSIS

The composition reported in the accompanying tables is, for the more extensive types, the average of several analyses. These analyses show that soils, like most things in nature, are variable; but for general purposes the average may be considered sufficient to characterize the soil type.

The chemical analysis of a soil, obtained by the methods here employed, gives the invoice of the total stock of the several plant-food materials actually present in the soil strata sampled and analyzed, but it should be understood that the rate of liberation, as explained in the Appendix, page 41, is governed by many factors.

THE SURFACE SOIL

In Table 2 are reported the amount of organic carbon (the best measure of the organic matter) and the total amounts of the six important elements of plant food—nitrogen, phosphorus, sulfur, potassium, magnesium, and calcium—contained in 2 million pounds of the surface soil of each type in Bureau county. Because of the inadequacy of information furnished by mere averages with respect to limestone content and soil acidity, these figures are not included in the tabulated results. For a more complete explanation of this point see note in the tables.

The variation among the different types of soil with respect to their content of important plant-food elements is very marked. For example, the deep peat contains, in the plowed soil of an acre, 22 times as much nitrogen as the dune sand, but it carries only one-fourth as much potassium as the brown silt loam. Similar variations are found with respect to the other elements.

It is important to note that some of the plant-food elements are present in very limited quantities as compared with crop requirements. Some simple computations are of interest in this connection. Take, for example, a four-field crop rotation of wheat, corn, oats, and clover. Assuming yields of 50 bushels of wheat per acre, 100 bushels of corn, 100 bushels of oats, and 4 tons of clover, it will be found that the most common soil of Bureau county, the brown silt loam of the prairie, does not contain more than enough total nitrogen in the plowed soil for the production of such yields for nine rotations (36 years), and the other extensive upland soils in the county are even poorer in this element.

With respect to phosphorus the condition differs only in degree. The brown silt loam contains no more of this element than would be required for fifteen crop rotations if such yields were secured as are suggested above. On the other hand, the potassium in the surface layer of this common soil type is sufficient for about 25 centuries if only the grain is sold, or for about 400 years even if the total crops should be removed and nothing returned.

These general statements relating to the total quantities of these plant food materials in the plowed soil of the most prevalent type in the county certainly emphasize the fact that the supplies of some of these necessary elements of fertility are extremely limited when measured by the needs of large crop yields for even one or two generations of people.

THE SUBSURFACE AND SUBSOIL

In Tables 3 and 4 are recorded the amounts of plant food in the subsurface and the subsoil of the different types of soil in Bureau county. It should be remembered, however, that these supplies are of little value unless the top soil is kept rich. These tables also show great stores of potassium and only limited amounts of nitrogen and phosphorus, in agreement with the data for the surface stratum presented in Table 2.

TABLE 2.—PLANT FOOD IN THE SOILS OF BUREAU COUNTY, ILLINOIS: SURFACE SOIL

Average pounds per acre in 2 million pounds of surface soil (about 0–6 ⅔ inches)

Soil type No.	Soil type	Total organic carbon	Total nitrogen	Total phosphorus	Total sulfur	Total potassium	Total magnesium	Total calcium	Limestone and soil acidity
	(a) Upland Prairie Soils (200, 500, 700, 900, 1100)								
-26	Brown silt loam	56 440	4 810	1 190	800	31 820	8 160	13 220	
-60	Brown sandy loam	27 190	2 390	670	580	21 890	4 600	6 140	
-20	Black clay loam	85 520	7 760	2 460	1 620	28 660	12 920	24 240	
-25	Black silt loam	117 780	9 340	2 340	1 780	29 520	11 260	25 520	
-28 1528	Brown-gray silt loam on tight clay	47 340	4 420	1 420	980	32 160	5 020	8 760	
-81	Dune sand	12 420	1 020	480	260	17 280	3 720	5 480	
-90 1590	Gravelly loam	25 040	2 600	760	780	31 840	47 520	91 420	
	(b) Upland Timber Soils (200, 500, 700, 900, 1100)								
-34	Yellow-gray silt loam	40 480	3 910	1 240	700	32 200	5 960	12 050	
-35	Yellow silt loam	25 900	2 320	730	560	35 610	4 930	9 480	
-64	Yellow-gray sandy loam	18 360	1 440	460	380	23 260	3 360	6 080	
	(c) Terrace Soils (1500)								
-27	Brown silt loam over gravel	46 620	4 070	1 040	800	31 030	8 130	12 610	
-60	Brown sandy loam	36 100	3 080	1 000	860	22 540	4 800	8 100	
-61	Black sandy loam	74 640	7 100	1 560	1 080	22 400	7 700	19 500	
-81	Dune sand	13 940	1 160	780	320	18 660	4 340	9 340	
-50	Black mixed loam	121 340	11 780	2 500	1 620	17 040	16 020	172 300	
-25	Black silt loam	109 860	11 200	2 700	1 840	28 100	17 810	72 580	
-64	Yellow-gray sandy loam	28 020	2 160	980	640	29 160	4 780	10 980	
-71	Brown fine sandy loam	50 720	4 160	1 180	640	27 720	5 340	9 500	
-20 1420	Black clay loam	86 560	7 240	2 520	1 360	31 580	14 740	25 600	
-68	Brown-gray sandy loam on tight clay	40 240	3 410	970	650	24 880	4 210	9 510	

In connection with these tabulated data it should be explained that the figures on limestone content and soil acidity are omitted not because of any lack of importance of these factors, but rather because of the peculiar difficulty of presenting in general averages adequate information concerning the limestone requirement. The limestone requirement for soils is extremely variable. It may vary from farm to farm, and even from field to field. Therefore no at-

TABLE 2.—PLANT FOOD IN THE SOILS OF BUREAU COUNTY, ILLINOIS: SURFACE SOIL, *Concluded*

Soil type No.	Soil type	Total organic carbon	Total nitrogen	Total phosphorus	Total sulfur	Total potassium	Total magnesium	Total calcium	Limestone and soil acidity
	(c) Terrace Soils (1500), *Concluded*								
-36	Yellow-gray silt loam over gravel	18 880	1 920	760	700	33 420	7 200	11 340	tempt is made to include in these tables figures purporting to represent for the various types the limestone content or the soil acidity present. The need for limestone should be determined on every farm and for each field individually. Fortunately this can be easily done by the simple tests described in the Appendix to this report, page 43.
-64.4	Yellow-gray sandy loam on gravel	20 020	1 640	620	660	31 820	3 680	6 380	
-60.4	Brown sandy loam on gravel	22 900	1 680	680	480	25 900	3 520	5 400	
-28, 228, 528, 1128	Brown-gray silt loam on tight clay	47 340	4 420	1 420	980	32 160	5 020	8 760	
-90, 290, 790, 990, 1190	Gravelly loam	25 040	2 600	760	780	31 840	47 520	91 420	
	(d) Swamp and Bottom-Land Soils (1300, 1400)								
-54	Mixed loam	56 390	5 170	1 720	810	41 240	10 380	16 590	
-01	Deep peat[1]	253 590	22 630	1 820	3 800	8 080	7 150	26 110	
-02	Medium peat on clay[1]	257 570	22 650	1 500	3 250	6 420	5 670	27 770	
-10	Peaty loam	152 250	13 920	1 620	1 080	20 600	9 780	44 540	
-20, 1520	Black clay loam	86 560	7 240	2 520	1 360	31 580	14 740	25 600	
-25	Black silt loam	155 000	13 960	2 540	2 860	26 620	12 660	34 680	
-26	Deep brown silt loam	86 740	7 220	2 080	1 460	41 960	14 840	43 520	
-50	Black mixed loam	105 160	10 160	1 800	1 120	24 600	5 500	16 000	
-61	Black sandy loam	114 920	11 000	1 900	2 180	25 260	12 200	33 240	

[1]Amounts reported are for 1 million pounds of deep peat and medium peat.

TABLE 3.—PLANT FOOD IN THE SOILS OF BUREAU COUNTY, ILLINOIS: SUBSURFACE SOIL
Average pounds per acre in 4 million pounds of subsurface soil (about $6\frac{2}{3}$–20 inches)

Soil type No.	Soil type	Total organic carbon	Total nitrogen	Total phosphorus	Total sulfur	Total potassium	Total magnesium	Total calcium	Limestone and soil acidity
	(a) Upland Prairie Soils (200, 500, 700, 900, 1100)								
-26	Brown silt loam	61 750	5 450	3 060	1 170	64 900	20 560	23 160	
-60	Brown sandy loam	35 130	3 170	1 230	910	48 990	11 770	11 160	
-20	Black clay loam	79 480	7 480	3 240	1 760	62 160	28 520	44 760	
-25	Black silt loam	112 280	7 880	3 720	1 280	57 760	18 720	37 440	
-28 1528	Brown-gray silt loam on tight clay	39 480	4 040	1 760	11 560	69 960	12 080	20 440	
-81	Dune sand	14 080	1 040	720	440	31 920	6 480	10 920	
-90 1590	Gravelly loam	26 840	2 680	1 600	1 520	66 160	129 840	283 920	
	(b) Upland Timber Soils (200, 500, 700, 900, 1100)								
-34	Yellow-gray silt loam	23 010	2 680	1 560	660	67 120	21 250	21 230	
-35	Yellow silt loam	13 620	1 580	1 400	740	75 940	16 760	22 040	
-64	Yellow-gray sandy loam	14 040	1 240	880	240	41 800	6 660	10 200	
	(c) Terrace Soils (1500)								
-27	Brown silt loam over gravel	60 350	5 390	1 840	1 640	64 870	18 890	21 990	
-60	Brown sandy loam	38 480	3 560	1 640	1 200	50 080	11 000	15 320	
-61	Black sandy loam	50 760	5 040	2 400	1 040	49 680	18 320	34 120	
-81	Dune sand	18 400	1 600	1 480	560	35 360	7 040	16 880	
-50	Black mixed loam	89 720	8 200	3 160	920	36 640	41 160	345 360	
-25	Black silt loam	184 880	15 960	4 840	2 400	50 680	35 380	122 440	
-64	Yellow-gray sandy loam	16 040	1 960	1 840	1 000	65 440	14 560	16 080	
-71	Brown fine sandy loam	44 400	3 880	1 680	600	60 320	11 760	16 800	
-20 1420	Black clay loam	98 440	8 240	3 920	1 680	67 640	26 960	44 600	
-68	Brown-gray sandy loam on tight clay	33 420	3 040	1 460	1 000	54 180	10 740	16 480	

In connection with these tabulated data it should be explained that the figures on limestone content and soil acidity are omitted not because of any lack of importance of these factors, but rather because of the peculiar difficulty of presenting in general averages adequate information concerning the limestone requirement. The limestone requirement for soils is extremely variable. It may vary from farm to farm, and even from field to field. Therefore no at-

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Soil type No.	Soil type	Total organic carbon	Total nitrogen	Total phosphorus	Total sulfur	Total potassium	Total magnesium	Total calcium	Limestone and soil acidity
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-36	Yellow-gray silt loam over gravel	13 560	1 960	2 040	920	68 680	20 200	22 280	tempt is made to include in these tables figures purporting to represent for the various types the limestone content or the soil acidity present. The need for limestone should be determined on every farm and for each field individually. Fortunately this can be easily done by the simple tests described in the Appendix to this report, page 43.
-64.4	Yellow-gray sandy loam on gravel	11 520	1 080	1 400	480	65 560	9 040	12 160	
-60.4	Brown sandy loam on gravel	26 760	2 320	1 400	840	53 320	7 720	9 800	
-28 228 528 1128	Brown-gray silt loam on tight clay	39 480	4 040	1 760	11 560	69 960	12 080	20 440	
-90 290 790 990 1190	Gravelly loam	26 840	2 680	1 600	1 520	66 160	129 840	283 920	
	(d) Swamp and Bottom-Land Soils (1300, 1400)								
-54	Mixed loam	82 460	7 640	3 000	1 480	83 680	26 560	40 920	
-01	Deep peat[1]	506 730	45 070	3 230	7 980	12 600	12 780	56 670	
-02	Medium peat on clay[1]	226 300	20 480	1 860	2 960	20 800	11 980	47 520	
-10	Peaty loam	89 080	7 540	1 820	1 960	41 300	8 420	220 120	
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-26	Deep brown silt loam	98 280	8 400	3 240	1 760	77 640	34 520	78 560	
-50	Black mixed loam	105 400	9 840	2 520	960	50 640	6 720	26 280	
-61	Black sandy loam	98 680	9 520	3 000	1 800	57 640	29 320	56 960	

[1]Amounts reported are for 2 million pounds of deep peat and medium peat.

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It is important to note that some of the plant-food elements are present in very limited quantities as compared with crop requirements. Some simple computations are of interest in this connection. Take, for example, a four-field crop rotation of wheat, corn, oats, and clover. Assuming yields of 50 bushels of wheat per acre, 100 bushels of corn, 100 bushels of oats, and 4 tons of clover, it will be found that the most common soil of Bureau county, the brown silt loam of the prairie, does not contain more than enough total nitrogen in the plowed soil for the production of such yields for nine rotations (36 years), and the other extensive upland soils in the county are even poorer in this element.

With respect to phosphorus the condition differs only in degree. The brown silt loam contains no more of this element than would be required for fifteen crop rotations if such yields were secured as are suggested above. On the other hand, the potassium in the surface layer of this common soil type is sufficient for about 25 centuries if only the grain is sold, or for about 400 years even if the total crops should be removed and nothing returned.

These general statements relating to the total quantities of these plant food materials in the plowed soil of the most prevalent type in the county certainly emphasize the fact that the supplies of some of these necessary elements of fertility are extremely limited when measured by the needs of large crop yields for even one or two generations of people.

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Average pounds per acre in 2 million pounds of surface soil (about 0–6⅔ inches)

Soil type No.	Soil type	Total organic carbon	Total nitrogen	Total phosphorus	Total sulfur	Total potassium	Total magnesium	Total calcium	Limestone and soil acidity
	(a) Upland Prairie Soils (200, 500, 700, 900, 1100)								
-26	Brown silt loam	56 440	4 810	1 190	800	31 820	8 160	13 220	
-60	Brown sandy loam	27 190	2 390	670	580	21 890	4 600	6 140	
-20	Black clay loam	85 520	7 760	2 460	1 620	28 660	12 920	24 240	
-25	Black silt loam	117 780	9 340	2 340	1 780	29 520	11 260	25 520	
-28 { 1528 {	Brown-gray silt loam on tight clay	47 340	4 420	1 420	980	32 160	5 020	8 760	
-81	Dune sand	12 420	1 020	480	260	17 280	3 720	5 480	
-90 { 1590 {	Gravelly loam	25 040	2 600	760	780	31 840	47 520	91 420	
	(b) Upland Timber Soils (200, 500, 700, 900, 1100)								
-34	Yellow-gray silt loam	40 480	3 910	1 240	700	32 200	5 960	12 050	
-35	Yellow silt loam	25 900	2 320	730	560	35 610	4 930	9 480	
-64	Yellow-gray sandy loam	18 360	1 440	460	380	23 260	3 360	6 080	
	(c) Terrace Soils (1500)								
-27	Brown silt loam over gravel	46 620	4 070	1 040	800	31 030	8 130	12 610	
-60	Brown sandy loam	36 100	3 080	1 000	860	22 540	4 800	8 100	
-61	Black sandy loam	74 640	7 100	1 560	1 080	22 400	7 700	19 500	
-81	Dune sand	13 940	1 160	780	320	18 660	4 340	9 340	
-50	Black mixed loam	121 340	11 780	2 500	1 620	17 040	16 020	172 300	
-25	Black silt loam	109 860	11 200	2 700	1 840	28 100	17 810	72 580	
-64	Yellow-gray sandy loam	28 020	2 160	980	640	29 160	4 780	10 980	
-71	Brown fine sandy loam	50 720	4 160	1 180	640	27 720	5 340	9 500	
-20 { 1420 {	Black clay loam	86 560	7 240	2 520	1 360	31 580	14 740	25 600	
-68	Brown-gray sandy loam on tight clay	40 240	3 410	970	650	24 880	4 210	9 510	

(Limestone and soil acidity column:) In connection with these tabulated data it should be explained that the figures on limestone content and soil acidity are omitted not because of any lack of importance of these *factors*, but rather because of the peculiar difficulty of presenting in general averages adequate information concerning the limestone requirement. The limestone requirement for soils is extremely variable. It may vary from farm to farm, and even from field to field. Therefore no at-

TABLE 2.—PLANT FOOD IN THE SOILS OF BUREAU COUNTY, ILLINOIS: SURFACE SOIL, *Concluded*

Soil type No.	Soil type	Total organic carbon	Total nitrogen	Total phosphorus	Total sulfur	Total potassium	Total magnesium	Total calcium	Limestone and soil acidity
				(c) Terrace Soils (1500), *Concluded*					
-36	Yellow-gray silt loam over gravel	18 880	1 920	760	700	33 420	7 200	11 340	tempt is made to include in these tables figures purporting to represent for the various types the limestone content or the soil acidity present. The need for limestone should be determined on every farm and for each field individually. Fortunately this can be easily done by the simple tests described in the Appendix to this report, page 43.
-64.4	Yellow-gray sandy loam on gravel	20 020	1 640	620	660	31 820	3 680	6 380	
-60.4	Brown sandy loam on gravel	22 900	1 680	680	480	25 900	3 520	5 400	
-28, 228, 528, 1128	Brown-gray silt loam on tight clay	47 340	4 420	1 420	980	32 160	5 020	8 760	
-90, 290, 790, 990, 1190	Gravelly loam	25 040	2 600	760	780	31 840	47 520	91 420	
				(d) Swamp and Bottom-Land Soils (1300, 1400)					
-54	Mixed loam	56 390	5 170	1 720	810	41 240	10 380	16 590	
-01	Deep peat[1]	253 590	22 630	1 820	3 800	8 080	7 150	26 110	
-02	Medium peat on clay[1]	257 570	22 650	1 500	3 250	6 420	5 670	27 770	
-10	Peaty loam	152 250	13 920	1 620	1 080	20 600	9 780	44 540	
-20, 1520	Black clay loam	86 560	7 240	2 520	1 360	31 580	14 740	25 600	
-25	Black silt loam	155 000	13 960	2 540	2 860	26 620	12 660	34 680	
-26	Deep brown silt loam	86 740	7 220	2 080	1 460	41 960	14 840	43 520	
-50	Black mixed loam	105 160	10 160	1 800	1 120	24 600	5 500	16 000	
-61	Black sandy loam	114 920	11 000	1 900	2 180	25 260	12 200	33 240	

[1]Amounts reported are for 1 million pounds of deep peat and medium peat.

TABLE 3.—PLANT FOOD IN THE SOILS OF BUREAU COUNTY, ILLINOIS: SUBSURFACE SOIL

Average pounds per acre in 4 million pounds of subsurface soil (about $6\frac{2}{3}$–20 inches)

Soil type No.	Soil type	Total organic carbon	Total nitrogen	Total phosphorus	Total sulfur	Total potassium	Total magnesium	Total calcium	Limestone and soil acidity
	(a) Upland Prairie Soils (200, 500, 700, 900, 1100)								
-26	Brown silt loam	61 750	5 450	3 060	1 170	64 900	20 560	23 160	
-60	Brown sandy loam	35 130	3 170	1 230	910	48 990	11 770	11 160	
-20	Black clay loam	79 480	7 480	3 240	1 760	62 160	28 520	44 760	
-25	Black silt loam	112 280	7 880	3 720	1 280	57 760	18 720	37 440	
-28 } 1528 }	Brown-gray silt loam on tight clay	39 480	4 040	1 760	11 560	69 960	12 080	20 440	
-81	Dune sand	14 080	1 040	720	440	31 920	6 480	10 920	
-90 } 1590 }	Gravelly loam	26 840	2 680	1 600	1 520	66 160	129 840	283 920	
	(b) Upland Timber Soils (200, 500, 700, 900, 1100)								
-34	Yellow-gray silt loam	23 010	2 680	1 560	660	67 120	21 250	21 230	
-35	Yellow silt loam	13 620	1 580	1 400	740	75 940	16 760	22 040	
-64	Yellow-gray sandy loam	14 040	1 240	880	240	41 800	6 660	10 200	
	(c) Terrace Soils (1500)								
-27	Brown silt loam over gravel	60 350	5 390	1 840	1 640	64 870	18 890	21 990	
-60	Brown sandy loam	38 480	3 560	1 640	1 200	50 080	11 000	15 320	
-61	Black sandy loam	50 760	5 040	2 400	1 040	49 680	18 320	34 120	
-81	Dune sand	18 400	1 600	1 480	560	35 360	7 040	16 880	
-50	Black mixed loam	89 720	8 200	3 160	920	36 640	41 160	345 360	
-25	Black silt loam	184 880	15 960	4 840	2 400	50 680	35 380	122 440	
-64	Yellow-gray sandy loam	16 040	1 960	1 840	1 000	65 440	14 560	16 080	
-71	Brown fine sandy loam	44 400	3 880	1 680	600	60 320	11 760	16 800	
-20 } 1420 }	Black clay loam	98 440	8 240	3 920	1 680	67 640	26 960	44 600	
-68	Brown-gray sandy loam on tight clay	33 420	3 040	1 460	1 000	54 180	10 740	16 480	

In connection with these tabulated data it should be explained that the figures on limestone content and soil acidity are omitted not because of any lack of importance of these f a c t o r s, but rather because of the peculiar difficulty of presenting in general averages adequate information concerning the limestone requirement. The limestone requirement for soils is extremely variable. It may vary from farm to farm, and even from field to field. Therefore no at-

TABLE 3.—PLANT FOOD IN THE SOILS OF BUREAU COUNTY, ILLINOIS: SUBSURFACE SOIL, *Concluded*

Soil type No.	Soil type	Total organic carbon	Total nitrogen	Total phosphorus	Total sulfur	Total potassium	Total magnesium	Total calcium	Limestone and soil acidity
	(c) Terrace Soils (1500), *Concluded*								
-36	Yellow-gray silt loam over gravel	13 560	1 960	2 040	920	68 680	20 200	22 280	tempt is made to include in these tables figures purporting to represent for the various types the limestone content or the soil acidity present. The need for limestone should be determined on every farm and for each field individually. Fortunately this can be easily done by the simple tests described in the Appendix to this report, page 43.
-64.4	Yellow-gray sandy loam on gravel	11 520	1 080	1 400	480	65 560	9 040	12 160	
-60.4	Brown sandy loam on gravel	26 760	2 320	1 400	840	53 320	7 720	9 800	
-28, 228, 528, 1128	Brown-gray silt loam on tight clay	39 480	4 040	1 760	11 560	69 960	12 080	20 440	
-90, 290, 790, 990, 1190	Gravelly loam	26 840	2 680	1 600	1 520	66 160	129 840	283 920	
	(d) Swamp and Bottom-Land Soils (1300, 1400)								
-54	Mixed loam	82 460	7 640	3 000	1 480	83 680	26 560	40 920	
-01	Deep peat[1]	506 730	45 070	3 230	7 980	12 600	12 780	56 670	
-02	Medium peat on clay[1]	226 300	20 480	1 860	2 960	20 800	11 980	47 520	
-10	Peaty loam	89 080	7 540	1 820	1 960	41 300	8 420	220 120	
-20, 1520	Black clay loam	98 440	8 240	3 920	1 680	67 640	26 960	44 600	
-25	Black silt loam	113 040	10 520	4 280	2 520	53 680	32 080	83 000	
-26	Deep brown silt loam	98 280	8 400	3 240	1 760	77 640	34 520	78 560	
-50	Black mixed loam	105 400	9 840	2 520	960	50 640	6 720	26 280	
-61	Black sandy loam	98 680	9 520	3 000	1 800	57 640	29 320	56 960	

[1]Amounts reported are for 2 million pounds of deep peat and medium peat.

posed. The various agencies that have been at work in the formation and transportation of soil material necessarily give the soils of the county a varied character. In addition to the transporting agencies, the accumulation of organic matter has gone on in the swamps and, to a slightly less extent, upon the uplands, and this together with the mineral material, has added to the complexity of the soils.

Many of the smaller streams originally did not have distinct channels, but flowed sluggishly in broad shallow valleys, or "sloughs." In some cases the streams flowing into these from the upland were sufficiently swift to transport fine gravel and coarse sand, while in other cases nothing but the finer material was carried. This has given rise to soils that contain some gravel and sand in areas where normally only fine material would be found.

The soils of Bureau county are divided into the following classes:

(a) Upland Prairie Soils.—These are rich in organic matter. This land was originally covered with prairie grasses, the partly decayed roots of which have been the source of the organic matter. The flat prairie land contains a higher amount of this constituent than the undulating or rolling prairie, because the grasses and roots grew more luxuriantly there, and the higher moisture content retarded their decay.

The upland prairie soils include some areas of recent timber growth where certain kinds of trees have spread over the prairie, but this forestation has not been of sufficient duration to produce the characteristic timber soils. These areas, of greater or less width, are found along the border of most timber tracts, so that the timber actually extended a little farther than the soil type indicates.

(b) Upland Timber Soils.—These include a large part of the upland that was formerly covered with forests. These soils contain much less organic matter than the prairie soils, because the large roots of dead trees added but little, and the surface accumulations of leaves, twigs, and fallen trees were burned by forest fires or suffered almost complete decay. The timber lands are divided chiefly into two subclasses—the undulating and the hilly areas.

(c) Terrace Soils.—These include bench lands, or second bottom lands. They were formed by deposition from streams overloaded with coarse sediment during the melting of the glacier and subsequently. Finer deposits which were later made upon the coarse gravelly material now constitute the soil.

(d) Late Swamp and Bottom-Land Soils.—These include the present overflow lands, or flood plains of streams, and the very poorly drained lowlands, where peats and peaty loams have been formed.

Table 1 gives the area of each type of soil in Bureau county, and its percentage of the total area. The accompanying map shows the location and boundary of each type of soil, even when the type covers but a few acres.

INVOICE OF PLANT FOOD IN BUREAU COUNTY SOILS

SOIL ANALYSIS

The composition reported in the accompanying tables is, for the more extensive types, the average of several analyses. These analyses show that soils, like most things in nature, are variable; but for general purposes the average may be considered sufficient to characterize the soil type.

The chemical analysis of a soil, obtained by the methods here employed, gives the invoice of the total stock of the several plant-food materials actually present in the soil strata sampled and analyzed, but it should be understood that the rate of liberation, as explained in the Appendix, page 41, is governed by many factors.

THE SURFACE SOIL

In Table 2 are reported the amount of organic carbon (the best measure of the organic matter) and the total amounts of the six important elements of plant food—nitrogen, phosphorus, sulfur, potassium, magnesium, and calcium—contained in 2 million pounds of the surface soil of each type in Bureau county. Because of the inadequacy of information furnished by mere averages with respect to limestone content and soil acidity, these figures are not included in the tabulated results. For a more complete explanation of this point see note in the tables.

The variation among the different types of soil with respect to their content of important plant-food elements is very marked. For example, the deep peat contains, in the plowed soil of an acre, 22 times as much nitrogen as the dune sand, but it carries only one-fourth as much potassium as the brown silt loam. Similar variations are found with respect to the other elements.

It is important to note that some of the plant-food elements are present in very limited quantities as compared with crop requirements. Some simple computations are of interest in this connection. Take, for example, a four-field crop rotation of wheat, corn, oats, and clover. Assuming yields of 50 bushels of wheat per acre, 100 bushels of corn, 100 bushels of oats, and 4 tons of clover, it will be found that the most common soil of Bureau county, the brown silt loam of the prairie, does not contain more than enough total nitrogen in the plowed soil for the production of such yields for nine rotations (36 years), and the other extensive upland soils in the county are even poorer in this element.

With respect to phosphorus the condition differs only in degree. The brown silt loam contains no more of this element than would be required for fifteen crop rotations if such yields were secured as are suggested above. On the other hand, the potassium in the surface layer of this common soil type is sufficient for about 25 centuries if only the grain is sold, or for about 400 years even if the total crops should be removed and nothing returned.

These general statements relating to the total quantities of these plant food materials in the plowed soil of the most prevalent type in the county certainly emphasize the fact that the supplies of some of these necessary elements of fertility are extremely limited when measured by the needs of large crop yields for even one or two generations of people.

THE SUBSURFACE AND SUBSOIL

In Tables 3 and 4 are recorded the amounts of plant food in the subsurface and the subsoil of the different types of soil in Bureau county. It should be remembered, however, that these supplies are of little value unless the top soil is kept rich. These tables also show great stores of potassium and only limited amounts of nitrogen and phosphorus, in agreement with the data for the surface stratum presented in Table 2.

TABLE 2.—PLANT FOOD IN THE SOILS OF BUREAU COUNTY, ILLINOIS: SURFACE SOIL
Average pounds per acre in 2 million pounds of surface soil (about 0–6 ⅔ inches)

Soil type No.	Soil type	Total organic carbon	Total nitrogen	Total phosphorus	Total sulfur	Total potassium	Total magnesium	Total calcium	Limestone and soil acidity
	(a) Upland Prairie Soils (200, 500, 700, 900, 1100)								
-26	Brown silt loam	56 440	4 810	1 190	800	31 820	8 160	13 220	
-60	Brown sandy loam	27 190	2 390	670	580	21 890	4 600	6 140	
-20	Black clay loam	85 520	7 760	2 460	1 620	28 660	12 920	24 240	
-25	Black silt loam	117 780	9 340	2 340	1 780	29 520	11 260	25 520	
-28 1528	Brown-gray silt loam on tight clay	47 340	4 420	1 420	980	32 160	5 020	8 760	
-81	Dune sand	12 420	1 020	480	260	17 280	3 720	5 480	
-90 1590	Gravelly loam	25 040	2 600	760	780	31 840	47 520	91 420	
	(b) Upland Timber Soils (200, 500, 700, 900, 1100)								
-34	Yellow-gray silt loam	40 480	3 910	1 240	700	32 200	5 960	12 050	
-35	Yellow silt loam	25 900	2 320	730	560	35 610	4 930	9 480	
-64	Yellow-gray sandy loam	18 360	1 440	460	380	23 260	3 360	6 080	
	(c) Terrace Soils (1500)								
-27	Brown silt loam over gravel	46 620	4 070	1 040	800	31 030	8 130	12 610	
-60	Brown sandy loam	36 100	3 080	1 000	860	22 540	4 800	8 100	
-61	Black sandy loam	74 640	7 100	1 560	1 080	22 400	7 700	19 500	
-81	Dune sand	13 940	1 160	780	320	18 660	4 340	9 340	
-50	Black mixed loam	121 340	11 780	2 500	1 620	17 040	16 020	172 300	
-25	Black silt loam	109 860	11 200	2 700	1 840	28 100	17 810	72 580	
-64	Yellow-gray sandy loam	28 020	2 160	980	640	29 160	4 780	10 980	
-71	Brown fine sandy loam	50 720	4 160	1 180	640	27 720	5 340	9 500	
-20 1420	Black clay loam	86 560	7 240	2 520	1 360	31 580	14 740	25 600	
-68	Brown-gray sandy loam on tight clay	40 240	3 410	970	650	24 880	4 210	9 510	

In connection with these tabulated data it should be explained that the figures on limestone content and soil acidity are omitted not because of any lack of importance of these factors, but rather because of the peculiar difficulty of presenting in general averages adequate information concerning the limestone requirement. The limestone requirement for soils is extremely variable. It may vary from farm to farm, and even from field to field. Therefore no at-

TABLE 2.—PLANT FOOD IN THE SOILS OF BUREAU COUNTY, ILLINOIS: SURFACE SOIL, *Concluded*

Soil type No.	Soil type	Total organic carbon	Total nitrogen	Total phosphorus	Total sulfur	Total potassium	Total magnesium	Total calcium	Limestone and soil acidity
	(c) Terrace Soils (1500), *Concluded*								
-36	Yellow-gray silt loam over gravel	18 880	1 920	760	700	33 420	7 200	11 340	tempt is made to include in these tables figures purporting to represent for the various types the limestone content or the soil acidity present. The need for limestone should be determined on every farm and for each field individually. Fortunately this can be easily done by the simple tests described in the Appendix to this report, page 43.
-64.4	Yellow-gray sandy loam on gravel	20 020	1 640	620	660	31 820	3 680	6 380	
-60.4	Brown sandy loam on gravel	22 900	1 680	680	480	25 900	3 520	5 400	
-28, 228, 528, 1128	Brown-gray silt loam on tight clay	47 340	4 420	1 420	980	32 160	5 020	8 760	
-90, 290, 790, 990, 1190	Gravelly loam	25 040	2 600	760	780	31 840	47 520	91 420	
	(d) Swamp and Bottom-Land Soils (1300, 1400)								
-54	Mixed loam	56 390	5 170	1 720	810	41 240	10 380	16 590	
-01	Deep peat[1]	253 590	22 630	1 820	3 800	8 080	7 150	26 110	
-02	Medium peat on clay[1]	257 570	22 650	1 500	3 250	6 420	5 670	27 770	
-10	Peaty loam	152 250	13 920	1 620	1 080	20 600	9 780	44 540	
-20, 1520	Black clay loam	86 560	7 240	2 520	1 360	31 580	14 740	25 600	
-25	Black silt loam	155 000	13 960	2 540	2 860	26 620	12 660	34 680	
-26	Deep brown silt loam	86 740	7 220	2 080	1 460	41 960	14 840	43 520	
-50	Black mixed loam	105 160	10 160	1 800	1 120	24 600	5 500	16 000	
-61	Black sandy loam	114 920	11 000	1 900	2 180	25 260	12 200	33 240	

[1]Amounts reported are for 1 million pounds of deep peat and medium peat.

TABLE 3.—PLANT FOOD IN THE SOILS OF BUREAU COUNTY, ILLINOIS: SUBSURFACE SOIL
Average pounds per acre in 4 million pounds of subsurface soil (about $6\frac{2}{3}$-20 inches)

Soil type No.	Soil type	Total organic carbon	Total nitrogen	Total phosphorus	Total sulfur	Total potassium	Total magnesium	Total calcium	Limestone and soil acidity
	(a) Upland Prairie Soils (200, 500, 700, 900, 1100)								
-26	Brown silt loam	61 750	5 450	3 060	1 170	64 900	20 560	23 160	In connection with these tabulated data it should be explained that the figures on limestone content and soil acidity are omitted not because of any lack of importance of these factors, but rather because of the peculiar difficulty of presenting in general averages adequate information concerning the limestone requirement. The limestone requirement for soils is extremely variable. It may vary from farm to farm, and even from field to field. Therefore no at-
-60	Brown sandy loam	35 130	3 170	1 230	910	48 990	11 770	11 160	
-20	Black clay loam	79 480	7 480	3 240	1 760	62 160	28 520	44 760	
-25	Black silt loam	112 280	7 880	3 720	1 280	57 760	18 720	37 440	
-28 } 1528 }	Brown-gray silt loam on tight clay	39 480	4 040	1 760	11 560	69 960	12 080	20 440	
-81	Dune sand	14 080	1 040	720	440	31 920	6 480	10 920	
-90 } 1590 }	Gravelly loam	26 840	2 680	1 600	1 520	66 160	129 840	283 920	
	(b) Upland Timber Soils (200, 500, 700, 900, 1100)								
-34	Yellow-gray silt loam	23 010	2 680	1 560	660	67 120	21 250	21 230	
-35	Yellow silt loam	13 620	1 580	1 400	740	75 940	16 760	22 040	
-64	Yellow-gray sandy loam	14 040	1 240	880	240	41 800	6 660	10 200	
	(c) Terrace Soils (1500)								
-27	Brown silt loam over gravel	60 350	5 390	1 840	1 640	64 870	18 890	21 990	
-60	Brown sandy loam	38 480	3 560	1 640	1 200	50 080	11 000	15 320	
-61	Black sandy loam	50 760	5 040	2 400	1 040	49 680	18 320	34 120	
-81	Dune sand	18 400	1 600	1 480	560	35 360	7 040	16 880	
-50	Black mixed loam	89 720	8 200	3 160	920	36 640	41 160	345 360	
-25	Black silt loam	184 880	15 960	4 840	2 400	50 680	35 380	122 440	
-64	Yellow-gray sandy loam	16 040	1 960	1 840	1 000	65 440	14 560	16 080	
-71	Brown fine sandy loam	44 400	3 880	1 680	600	60 320	11 760	16 800	
-20 } 1420 }	Black clay loam	98 440	8 240	3 920	1 680	67 640	26 960	44 600	
-68	Brown-gray sandy loam on tight clay	33 420	3 040	1 460	1 000	54 180	10 740	16 480	

TABLE 3.—PLANT FOOD IN THE SOILS OF BUREAU COUNTY, ILLINOIS: SUBSURFACE SOIL, *Concluded*

Soil type No.	Soil type	Total organic carbon	Total nitrogen	Total phosphorus	Total sulfur	Total potassium	Total magnesium	Total calcium	Limestone and soil acidity
	(c) Terrace Soils (1500), *Concluded*								
-36	Yellow-gray silt loam over gravel	13 560	1 960	2 040	920	68 680	20 200	22 280	tempt is made to include in these tables figures purporting to represent for the various types the limestone content or the soil acidity present. The need for limestone should be determined on every farm and for each field individually. Fortunately this can be easily done by the simple tests described in the Appendix to this report, page 43.
-64.4	Yellow-gray sandy loam on gravel	11 520	1 080	1 400	480	65 560	9 040	12 160	
-60.4	Brown sandy loam on gravel	26 760	2 320	1 400	840	53 320	7 720	9 800	
-28, 228, 528, 1128	Brown-gray silt loam on tight clay	39 480	4 040	1 760	11 560	69 960	12 080	20 440	
-90, 290, 790, 990, 1190	Gravelly loam	26 840	2 680	1 600	1 520	66 160	129 840	283 920	
	(d) Swamp and Bottom-Land Soils (1300, 1400)								
-54	Mixed loam	82 460	7 640	3 000	1 480	83 680	26 560	40 920	
-01	Deep peat[1]	506 730	45 070	3 230	7 980	12 600	12 780	56 670	
-02	Medium peat on clay[1]	226 300	20 480	1 860	2 960	20 800	11 980	47 520	
-10	Peaty loam	89 080	7 540	1 820	1 960	41 300	8 420	220 120	
-20, 1520	Black clay loam	98 440	8 240	3 920	1 680	67 640	26 960	44 600	
-25	Black silt loam	113 040	10 520	4 280	2 520	53 680	32 080	83 000	
-26	Deep brown silt loam	98 280	8 400	3 240	1 760	77 640	34 520	78 560	
-50	Black mixed loam	105 400	9 840	2 520	960	50 640	6 720	26 280	
-61	Black sandy loam	98 680	9 520	3 000	1 800	57 640	29 320	56 960	

[1]Amounts reported are for 2 million pounds of deep peat and medium peat.

TABLE 4.—PLANT FOOD IN THE SOILS OF BUREAU COUNTY, ILLINOIS: SUBSOIL

Average pounds per acre in 6 million pounds of subsoil (about 20-40 inches)

Soil type No.	Soil type	Total organic carbon	Total nitrogen	Total phosphorus	Total sulfur	Total potassium	Total magnesium	Total calcium	Limestone and soil acidity
	(a) Upland Prairie Soils (200, 500, 700, 900, 1100)								
-26	Brown silt loam	26 330	3 040	2 690	1 140	97 940	42 630	51 460	In connection with these tabulated data it should be explained that the figures on limestone content and soil acidity are omitted not because of any lack of importance of these factors, but rather because of the peculiar difficulty of presenting in general averages adequate information concerning the limestone requirement. The limestone requirement for soils is extremely variable. It may vary from farm to farm, and even from field to field. Therefore no at-
-60	Brown sandy loam	20 180	1 560	1 420	980	68 060	16 440	17 700	
-20	Black clay loam	26 280	2 760	3 540	420	99 180	43 380	47 880	
-25	Black silt loam	43 260	3 240	3 360	1 020	78 180	66 300	109 560	
-28 } 1528 }	Brown-gray silt loam on tight clay	21 360	2 880	2 340	600	96 180	33 120	35 820	
-81	Dune sand	9 900	540	1 020	900	50 100	12 480	17 940	
-90 } 1590 }	Gravelly loam	14 820	1 740	2 280	1 440	102 840	239 340	517 140	
	(b) Upland Timber Soils (200, 500, 700, 900, 1100)								
-34	Yellow-gray silt loam	18 710	2 460	3 050	930	99 090	41 500	36 930	
-35	Yellow silt loam	12 930	2 070	2 910	900	122 790	41 340	33 180	
-64	Yellow-gray sandy loam	11 280	840	1 140	300	55 920	9 180	12 180	
	(c) Terrace Soils (1500)								
-27	Brown silt loam over gravel	33 440	3 500	2 620	1 420	94 840	35 780	39 500	
-60	Brown sandy loam	18 420	2 160	1 680	1 320	57 960	14 280	19 140	
-61	Black sandy loam	31 800	3 360	3 240	1 440	82 980	36 480	61 920	
-81	Dune sand	15 960	1 200	2 040	780	55 140	14 280	20 220	
-50	Black mixed loam	40 740	3 600	3 600	60	80 940	45 360	164 100	
-25	Black silt loam	64 260	8 880	5 300	1 740	81 540	59 590	193 980	
-64	Yellow-gray sandy loam	18 900	1 500	2 400	1 020	68 460	18 420	19 560	
-71	Brown fine sandy loam	23 820	2 040	1 800	1 080	83 700	18 840	27 060	
-20 } 1420 }	Black clay loam	51 780	5 100	4 320	1 920	104 640	43 080	53 940	
-68	Brown-gray sandy loam on tight clay	20 220	1 890	2 220	1 170	69 720	18 450	22 320	

TABLE 4.—PLANT FOOD IN THE SOILS OF BUREAU COUNTY, ILLINOIS: SUBSOIL, *Concluded*

Soil type No.	Soil type	Total organic carbon	Total nitrogen	Total phosphorus	Total sulfur	Total potassium	Total magnesium	Total calcium	Limestone and soil acidity
	(c) Terrace Soils (1500), *Concluded*								
-36	Yellow-gray silt loam over gravel	12 420	2 100	3 660	1 380	94 080	34 320	33 300	tempt is made to include in these tables figures purporting to represent for the various types the limestone content or the soil acidity present. The need for limestone should be determined on every farm and for each field individually. Fortunately this can be easily done by the simple tests described in the Appendix to this report, page 43.
-28, 228, 528, 1128	Brown-gray silt loam on tight clay	21 360	2 880	2 340	600	96 180	33 120	35 820	
-90, 290, 790, 990, 1190	Gravelly loam	14 820	1 740	2 280	1 440	102 840	239 340	517 140	
	(d) Swamp and Bottom-Land Soils (1300, 1400)								
-54	Mixed loam	51 480	4 890	3 600	1 140	114 180	80 850	155 580	
-01	Deep peat[1]	555 780	46 150	3 800	11 490	19 340	24 270	235 100	
-02	Medium peat on clay	366 940	5 820	3 240	1 800	60 540	39 330	625 860	
-10	Peaty loam	51 900	3 960	2 370	1 410	62 850	57 450	307 950	
-20, 1520	Black clay loam	51 780	5 100	4 320	1 920	104 640	43 080	53 940	
-25	Black silt loam	100 980	4 140	4 320	1 740	81 780	77 400	245 280	
-26	Deep brown silt loam	50 640	4 920	3 540	1 500	112 260	108 240	201 720	
-50	Black mixed loam	62 340	4 680	4 620	300	73 980	15 420	42 840	
-61	Black sandy loam	54 960	4 680	4 560	1 320	93 240	57 060	157 260	

[1]Amounts reported are for 3 million pounds of deep peat.

DESCRIPTION OF INDIVIDUAL SOIL TYPES

(a) UPLAND PRAIRIE SOILS

The upland prairie soils of Bureau county cover 492.77 square miles, or 57.01 percent of the area of the county. They are usually either brown or black in color, owing to the large organic-matter content. They occupy the less rolling, but not swampy, areas.

Brown Silt Loam (226, 526, 726, 926, 1126)

The brown silt loam is the most important as well as the most extensive type in Bureau county. It covers an area of 461.56 square miles, or 53.41 percent of the area of the entire county. This type occupies the slightly undulating to rolling areas of the prairie land, both morainal and intermorainal. The irregularities are due in a slight measure to erosion, but primarily to irregular deposition of material by the glaciers. While surface drainage is generally good, there are many places where the use of tile is necessary to remove the excess of water, and it is doubtless true that tile could be advantageously used to a greater extent than it is being used at present.

The soil is formed from a wind-blown or loessial material which covers the region to a depth of from two to twelve feet, the deeper deposit being over the Illinoisan and Iowan drift sheets. This material is mostly composed of the different grades of silt, the soil constituent intermediate in fineness. Altho brown silt loam is normally a prairie soil, yet in some limited areas forests have recently invaded it. They have not, however, changed it materially. These forests consist largely of black walnut, wild cherry, hackberry, ash, hard maple, and elm. A black-walnut soil is recognized generally by farmers as being one of the best timber soils because of the fact that it still contains a large amount of organic matter, characteristic of prairie soils. After the growth of several generations of trees, the organic matter may become so reduced that the soil would then be classed as a timber type.

The surface soil, 0 to 6⅔ inches, is a brown silt loam varying on the one hand to black as it grades into black clay loam (1120), or black silt loam (1125), and on the other hand to grayish brown or yellowish brown as it grades into the timber types. It contains a sufficient amount of the coarser constituents (coarse silt and fine sand) to make it work easily and yet enough fine silt and clay to give it stability and cause it to granulate. Where the brown silt loam occurs near the sandy loam, the type contains some sand and it may even include small areas of sandy loam that are not large enough to be shown on the map. It contains from 65 to 80 percent of silt, 10 to 15 percent of clay, and 15 to 30 percent of sand.

The organic-matter content varies from 3.7 to 6.6 percent, with an average of 5.2 percent, or 52 tons per acre. In the more rolling morainal areas there is less organic matter than in the low, richer, and poorly drained parts, the larger moisture content of the latter encouraging a ranker growth of grasses and roots and at the same time furnishing more favorable conditions for their pres-

ervation. The organic matter becomes less where the type grades into the yellow-gray silt loam (534, 934, and 1134).

The natural subsurface stratum varies from 9 to 16 inches in thickness, and from a dark brown or even black to a yellowish brown silt loam. Both color and depth vary with the topography, the type being lighter and shallower on the more rolling areas. Both the surface and subsurface are lighter in color where the type grades into the yellow-gray silt loam. The subsurface as sampled (6⅔ to 20 inches) contains 3.1 percent of organic matter, or 62 tons per acre. The natural subsurface is thicker in the lower, heavier, and poorly drained areas. This condition is due to the fact that deep cracks form in these low areas during periods of drouth, which allow some of the dark surface soil to be washed down by the rains, thus producing a deep layer of black soil.

The natural subsoil begins at a depth of 12 to 22 inches. It is a yellow or drabbish clayey silt or silty clay, somewhat plastic when wet. Where the drainage has been good, the color varies from a pale to a bright yellow, but where drainage has been poor it approaches a drab or an olive with pale yellow mottlings or a yellow with mottlings of drab, due to a lack of oxidation of iron.

The layer of loessial material is so deep that the drift rarely forms any part of the subsoil to a depth of 40 inches. Variations of the subsoil occur in limited areas adjacent to the sandy loam, and are due to the presence of more or less sand in the subsoil. In some small areas the subsoil passes into sand, indicating a sand deposit before the loess was deposited.

Treatment.—When the virgin brown silt loam was first cropped, the soil was in fine tilth, worked easily, and large crops could be grown with much less work than now. Continuous cropping, however, to corn or corn and oats with the burning of corn stalks, stubble, grass, and in many cases even straw, has destroyed the tilth in a great measure and now the soil is more difficult to work, washes badly, runs together, and bakes more readily. Unless the moisture conditions are very favorable, the ground plows up cloddy and unless well-distributed rains follow, a good seed bed is difficult to produce. The clods may remain all season. Much plant food is locked up in them and thus made unavailable, so that the best results cannot be obtained. This condition of poor tilth may become serious if the present methods of management continue; it is already one of the factors that limits crop yields. The remedy is to increase the organic-matter content by plowing under every available form of vegetable material, such as farm manure, corn stalks, straw, clover, stubble, and even weeds.

The deficiency of organic matter in the soils is shown by the way the fall-plowed land runs together during the winter. Much more work is required to produce a seed bed than was formerly the case. The result is that corn is frequently planted in poorly prepared seed beds and as a consequence it "fires" badly. Fall-plowed land should be disked early and deep for the purpose of conserving moisture, raising the temperature, and making plant food available.

The addition of fresh organic matter is not only of great value in improving the physical condition of this type of soil, but it is of even greater importance because of its nitrogen content and because of its power, as it decays, to liberate potassium from the inexhaustible supply in the minerals of the soil, and phosphorus from the phosphate contained in or applied to the soil.

For permanent, profitable systems of farming on brown silt loam, phosphorus should be applied liberally; and sufficient organic matter should be provided to furnish the necessary amount of nitrogen. On much of the type, limestone is already becoming deficient. An application of 2 tons of limestone, where needed, and ½ ton of finely ground rock phosphate per acre every four years, with the return to the soil of all manure made from a rotation of corn, corn, oats, and clover, will maintain the fertility of this type, altho heavier applications of phosphate may well be made during the first two or three rotations, and the first application of limestone may well be 4 tons per acre. If grain farming is practiced, the rotation may be wheat, corn, oats, and clover, with an extra seeding of clover (preferably sweet clover) as a cover crop in the wheat, to be plowed under late in the fall or in the following spring for corn; and most of the crop residues, including the clover chaff from the seed crops, should also be plowed under. In live-stock farming, the regular rotation may be extended to five or six years by seeding both timothy and clover with the oats, and pasturing one or two years. Alsike may well replace red clover at times, in order to avoid clover sickness. In either system, alfalfa may be grown on a fifth field and moved every five years, the hay being fed or sold. For results secured in field experiments on brown silt loam, see page 52 of the Supplement.

Brown Sandy Loam (260, 560, 760, 960, 1160)

Brown sandy loam occurs chiefly in the western part of the county. It covers 20.21 square miles, or 2.34 percent of the area of the county. In topography it is somewhat undulating, owing to the fact that sand was deposited over much of the area in the form of low dunes. The soil was later formed from this sand. In other areas, the undulating character of the surface is due to irregular deposition of the glacial drift, while in still others the irregularities are due to erosion. In these latter cases sand has been added to the soil thru the agency of wind. Small areas of brown sandy loam have been covered with forest, but not long enough to change the character of the soil to any extent.

The surface soil, 0 to 6⅔ inches, is a brown sandy loam, varying in color from black to light brown or yellowish brown. In sand content it varies from 50 to 80 percent, but the larger part of the area is of the more sandy phase, with approximately 65 to 70 percent of sand. The organic-matter content of the surface stratum varies from 1.6 to 3.4 percent, with an average of 2.3 percent, or 23 tons per acre. The amount is less in the more sandy phase, which usually occupies the more rolling or dune-like parts.

The natural subsurface varies from 6 to 18 inches in thickness and is mostly yellowish brown, brownish yellow, and yellow in color. The subsurface is not separated from the subsoil by a distinct line, but passes into it gradually, as indicated by the gradual change in color, and usually by an increase in sand content. The stratum is deeper on well-drained areas where roots are able to penetrate to a considerable depth. The amount of organic matter in the stratum sampled (6⅔ to 20 inches) varies from 1.3 to 1.7 percent, averaging 1.5 percent, or 30 tons per acre.

The natural subsoil begins at a depth of 12 to 24 inches. It varies in physical composition from a sandy silt to a yellow medium sand. The stratum 20 to 40 inches contains about .6 percent of organic matter.

Treatment.—This type is generally well drained. A few small areas need artificial drainage.

In the management of brown sandy loam, the organic matter should be increased or at least maintained by turning under farm manure, crop residues, and legumes. Organic matter, in addition to furnishing nitrogen, will prevent the movement of sand by the wind, which is very likely to take place on the more sandy areas as the organic content is diminished. On the very sandy areas, cowpeas or sweet clover are good legumes to grow. Ground limestone and organic manures are of the greatest importance in the improvement of this soil. While the total supply of phosphorus is much less than in the brown silt loam, the porous character of the subsurface and subsoil, which affords a deep feeding range for plant roots, is likely to more than counterbalance this lack, so that the application of phosphorus is not advised except where other limiting soil factors have been provided for. Initial applications of 3 to 4 tons per acre of limestone should be made with about 2 tons every four or five years thereafter.

Black Clay Loam (520, 920, 1120)

Black clay loam is one of the types that represent the flat, heavy, prairie land that is sometimes called "gumbo," because of its sticky character. Its formation in the flat, poorly drained areas is due to the accumulation of organic matter and the washing in of clay and fine silt from the slightly higher adjoining lands. This type occupies 979 acres, or .18 percent of the area of the county.

The surface soil, 0 to 6⅔ inches, is a black, granular, plastic clay loam varying to black clayey silt loam. It contains about 7.4 percent of organic matter, or 74 tons per acre.

The natural subsurface stratum has a thickness of 10 to 16 inches, and varies from a black at the top to a pale yellowish drab clay loam, usually somewhat heavier than the surface soil. The stratum as sampled (6⅔ to 20 inches) contains about 3.4 percent of organic matter, or 68 tons per acre. The stratum is pervious to water, owing principally to the jointing or checking from shrinkage in times of drouth.

The subsoil to a depth of 40 inches varies from a drab to a yellowish drab silty clay. As a rule, the iron is not highly oxidized, because of poor drainage and lack of aeration. Concretions of carbonate of lime are sometimes found. The perviousness of the subsoil is about the same as that of the subsurface, and is due to the same cause. When thrown out on the surface where wetting and drying may take place, it soon breaks into small cubical masses.

Black clay loam grades into other types, especially into black silt loam and brown silt loam. The washing in of silty material from the higher surrounding land, especially near the edges of the area, gives the surface a silty character. This change is taking place more rapidly now than formerly, when washing was largely prevented by prairie grasses.

Treatment.—Drainage is the first requirement in the management of this type. It is easily tile drained where an outlet is obtainable. Keeping the soil in good tilth is very essential, and thoro drainage helps to do this to a great extent.

As the organic matter is destroyed by cultivation and nitrification, and as the limestone is removed by cropping and leaching, the physical condition of

the soil becomes poorer, and as a consequence it becomes more difficult to work. Both organic matter and limestone develop granulation, a very necessary condition for maintaining the tilth, especially of heavy soils. The organic matter should be maintained by turning under farm manure and crop residues, such as corn stalks and straw, and by the use of clovers and pasture in rotations.

Altho the sample collected in Bureau county shows no limestone present, this type is likely to vary in this respect. It is therefore advisable to apply the simple tests for limestone described in the Appendix (page 43), and in case limestone is not present this material should be applied at the rate of at least 2 tons per acre.

While black clay loam is one of the best soils in the state, yet the clay and humus which it contains give it the property of shrinkage and expansion to such a degree as to be somewhat objectionable at times, especially during drouth. When the soil is wet, these constituents expand, and when the moisture evaporates or is used by the crops, they shrink. This results in the formation of cracks which are sometimes as much as two or more inches in width at the surface and extend with lessening width to two or three feet in depth. These cracks allow the soil strata to dry out rapidly, and as a result the crop is injured thru lack of moisture. They may do considerable damage by "blocking out" hills of corn and severing the roots. While cracking may not be prevented entirely, good tilth and a soil mulch will do much toward that end. Both for aeration and as a means of producing a mulch for conserving moisture, cultivation is more essential on this type than on the lighter types of soil. It must be remembered, however, that cultivation should be as shallow as possible in order to avoid injuring the roots of the corn.

The results of field experiments on this type of soil are given on page 64 of the Supplement.

Black Silt Loam (225, 525, 725, 925, 1125)

Black silt loam occupies low, flat areas or sloughs, occurring in situations somewhat similar to those of the black clay loam (—20), but it has had more of the coarser material washed in, and as a result is somewhat friable and silty. It covers a total area of 4,813 acres. In topography, this type is flat and naturally poorly drained.

The surface soil, 0 to 6⅔ inches, is a black silt loam varying on the one hand to brown silt loam, and on the other to black clay loam, and even grading toward muck in some cases. It is quite granular, and as a result is very pervious to both air and water. It contains 10.1 percent of organic matter, or 101 tons per acre. This is one of the richest soils in organic matter excepting the peats.

The natural subsurface is from 12 to 16 inches thick, and is a black to a dark brown clayey silt loam becoming drab or yellowish drab at the beginning of the subsoil. The subsurface stratum (6⅔ to 20 inches) contains 4.9 percent of organic matter, or 98 tons per acre.

The subsoil is a yellow or drabbish yellow clayey silt that permits free movement of water.

Treatment.—In the management of this type the same precautions should be observed with respect to drainage and the maintenance of organic matter as in the management of black clay loam.

Brown-Gray Silt Loam on Tight Clay (228, 528, 1128)

Brown-gray silt loam on tight clay is found only in small isolated areas that cover altogether but 83 acres. These areas usually occupy depressions in which some peculiar conditions of drainage have produced this soil.

The surface soil, 0 to 6⅔ inches, is a brown silt loam with areas of a grayish tint, especially when the soil becomes dry following a rain. The surface stratum contains about 4.1 percent of organic matter, or 41 tons per acre.

The subsurface is a gray silt loam becoming more yellow as the subsoil is approached. It is slowly pervious to water. This stratum contains 1.7 percent of organic matter. A sudden decrease in the organic matter content of the subsurface is characteristic of this type.

The subsoil is a tough, plastic, impervious clay, of a brownish gray or yellow color.

Treatment.—The first requirement of this type is good drainage, and this is somewhat difficult to secure at first because of the impervious character of the soil. After the soil is thoroly tile-drained, from 3 to 5 tons per acre of crushed limestone should be applied, and deep rooting crops, such as red, mammoth, or preferably sweet clover, should be grown. These legumes, along with any available manure and crop residues, should be turned under for soil improvement. Applications of from ½ to 1 ton per acre of rock phosphate should be made every four or five years until 2 tons have been applied.

Dune Sand (581, 781, 981, 1181)

The dune sand on the upland occurs as small, irregular patches scattered over the sandy-loam areas and widely distributed over the west half of the county. They represent the higher dunes of this county, which have never been covered with finer material or from which the fine material has been removed by wind and water. The total area is 160 acres, or .02 percent of the area of the county. This dune sand type does not differ from the terrace dune sand, and for further discussion of its character and treatment the reader is referred to the description of terrace dune sand (page 25).

Gravelly Loam (290, 790, 990, 1190)

Gravelly loam occurs principally in Towns 15 and 16 North, Range 7 East, in small irregular areas, and covers altogether 1,005 acres in this county.

The surface soil, 0 to 6⅔ inches, is a brown gravelly loam containing 2.2 percent of organic matter, or 22 tons per acre.

The subsurface is a light brown gravelly sandy loam, having an organic-matter content of 1.1 percent.

The subsoil is a yellowish or brownish gravel.

Treatment.—Where this type does not contain too much coarse material, good crops may be grown. It is necessary that the organic matter be maintained or even increased.

(b) UPLAND TIMBER SOILS

The upland timber soils occur as irregular zones along streams and on or near somewhat steep morainal ridges. They are characterized by a yellow, yel-

lowish gray, or gray color, which is due to their facilities for oxidation and to their low organic-matter content. The deficiency of organic matter has been caused by the long-continued growth of forest trees. After the forest invaded the prairies two effects were produced: first, the shade from the trees prevented the growth of prairie grasses, the roots of which are mainly responsible for the large organic-matter content in prairie soils; second, the trees themselves added very little organic matter to the soil, for the leaves and branches either decayed completely or were burned by forest fires. Furthermore, the organic matter that had been produced by the prairie grasses became gradually dissipated during the occupation of the land by the trees. As a result, the organic-matter content of the upland timber soils has been reduced until it is decidedly lower than that of the adjacent prairie land. Several generations of trees were necessary to produce the present condition of the soil.

The upland timber soils comprize 135.46 square miles, or 15.67 percent of the entire area of the county.

Yellow-Gray Silt Loam (234, 534, 734, 934, 1134)

Yellow-gray silt loam generally occurs in the outer timber belts along streams. The type covers 78.37 square miles, or about 9 percent of the entire area of the county. In topography it is sufficiently rolling for fair surface drainage without much tendency to wash if proper care is taken.

The surface soil, 0 to 6⅔ inches, is a yellow, yellowish gray, gray, or grayish brown, silt loam, pulverulent, but not granular. The more nearly level areas are gray in color, while the more rolling phase of the type is a grayish yellow or brownish yellow. As the type approaches the brown silt loam it becomes decidedly darker. The organic-matter content varies from 2 to 3.5 percent, with an average of 2.6 percent, or 26 tons per acre. The greatest variation in the organic-matter content is found in the more rolling areas where erosion has taken place.

In some places it is extremely difficult to draw the line between the long-cultivated and somewhat eroded brown silt loam, and the yellow-gray silt loam. This is especially true in some parts of the upper Illinoisan glaciation, notably in Town 14 North, Range 8 East, and Towns 15 North, Ranges 6 and 7 East. Here the brown silt loam is quite rolling and the slopes have in some cases eroded sufficiently so that they are mapped as yellow-gray silt loam. They probably never have been timbered.

The variation in texture of the surface stratum is due, to some extent, to the irregular deposition of sand by the wind. In some of the yellow-gray silt loam areas near the former extensive swamp, sand has been blown onto the uplands, thus increasing the normal amount of sand to such an extent that some very small areas, not sufficiently large to map, are sandy loams.

The natural subsurface stratum varies from 3 to 5 inches in thickness on the more rolling parts and from 8 to 14 inches on the more level areas, with an average of about 10 inches. It is usually a gray, grayish yellow, or yellow silt loam. The organic-matter content of the stratum sampled (6⅔ to 20 inches) varies from .6 to 1 percent, with an average of .8 percent, or 16 tons per acre. The physical composition of the subsurface varies with the surface.

The subsoil is a yellow or a mottled grayish yellow clayey silt or silty clay, somewhat plastic when wet, but friable when only moist. It is pervious to

water. The subsoil varies in physical composition even more than the surface stratum. Frequently boulder clay constitutes part or all of the subsoil. Sometimes sand may be encountered in the subsoil at a depth of from 30 to 40 inches. The sand was deposited by the wind previous to the deposition of the loess which constitutes most of the soil material of the upland in Bureau county.

This type drains well except on some of the more level and older forested areas, where a somewhat tough and tight clayey layer has developed that retards the movement of water.

Treatment.—In the management of yellow-gray silt loam, it is very necessary to maintain or even to increase the organic-matter content. This is necessary in order to supply nitrogen and liberate mineral plant foods; to give the soil better tilth; to prevent running together during heavy rains; and to prevent erosion on the more rolling phase. Rotations should be practiced that for a time at least will keep the soil in pasture, clover, or alfalfa, and reduce the tilled crops to a minimum acreage.

The samples analyzed showed considerable acidity especially in the subsurface. In such cases ground limestone should be applied in order that legumes may be grown successfully. An initial application of 2 to 4 tons per acre is suggested, after which 1 to 2 tons per acre every four or five years will probably be sufficient. Since the soil is poor in phosphorus, this element should be applied. In permanent systems of farming, finely ground natural rock phosphate will be found the most economical form in which to supply the phosphorus, altho when prices are normal steamed bone meal or acid phosphate may well be used temporarily until plenty of decaying organic matter can be provided.

For results from practical field experiments upon yellow-gray silt loam, see page 65 of the Supplement.

Yellow Silt Loam (235, 535, 735, 935, 1135)

Yellow silt loam occurs as hilly and badly eroded land on the inner timber belts adjacent to the streams, usually in narrow irregular strips with arms extending up the small valleys. The type covers an area of 56.88 square miles, or 6.58 percent of the area of the county.

The surface soil, 0 to 6⅔ inches, is a yellow or grayish yellow friable silt loam. It varies greatly in color, owing to recent erosion. In places the natural subsoil may be exposed, and this gives it a decidedly yellow color. When freshly plowed the soil appears yellow or grayish yellow, but when it becomes dry after a rain it is decidedly gray. The surface soil in some places may be composed of boulder clay, which usually contains more or less gravel. The area of this, however, is very limited. Near sandy-loam areas the surface soil may be somewhat sandy and may even become a sandy loam, but these areas are usually too small to be shown on the map. The organic-matter content varies from 2 to 2.4 percent, with an average of 2.2 percent, or 22 tons per acre.

The natural subsurface varies from an inch or two to 12 inches in thickness, and is usually a yellow silt loam, altho on the steepest slopes it may consist of a clayey silt loam. In other places it may contain a considerable amount of sand. The organic-matter content of the stratum sampled (6⅔ to 20 inches) is about 14 tons per acre.

The subsoil is normally a yellow clayey silt. On the more eroded areas, however, it may be composed in part or entirely of boulder clay or drift, and

where the wind has transported a great deal of sand the subsoil may be sandy or even a sand.

Treatment.—The first and most important point in the management of this type is the prevention of general surface-washing and gullying. If the land is cropped at all a rotation should be practiced that will require cultivated crops as little as possible and allow pasture and meadow most of the time. If tilled, the land should be plowed deeply and contours should be followed as nearly as possible in plowing, planting, and cultivating. Furrows should not be made up and down the slopes. Every means should be employed to maintain and to increase the organic-matter content. This will help to hold the soil and keep it in good physical condition so that it will absorb a large amount of water and thus diminish the run-off. (See Bulletin 207, "Washing of Soils and Methods of Prevention.")

According to the analyses of the samples of yellow silt loam collected in Bureau county, limestone is sometimes present in the subsoil but none of this material is contained in the surface or subsurface. However, it is known that in this general region of the state limestone occasionally occurs in abundance in the subsurface stratum. In view of this fact, therefore, it is recommended that the test for soil acidity, as described in the Appendix, be made. If this test indicates the absence of limestone near the surface, then this material should be applied at the rate of 2 to 4 tons per acre.

One of the best crops to be grown on land that is gullied or is likely to wash badly is sweet clover. This furnishes a large amount of good pasture and encourages the growth of blue-grass. Both the clover and the blue-grass tend to hold the soil and prevent washing. Alfalfa is another good legume crop to be grown on this type of soil. It will be useless, however, to sow either sweet clover or alfalfa if the soil is acid.

For an account of experiments with yellow silt loam soil the reader is referred to page 67 of the Supplement.

Yellow-Gray Sandy Loam (964, 1164)

The total area of yellow-gray sandy loam amounts to but 134 acres. It occurs along Bureau creek where the sand has been blown onto the upland.

The surface soil, 0 to 6⅔ inches, contains 1.6 percent of organic matter, or 16 tons per acre, and consists of a yellow or a grayish yellow sandy loam.

The subsurface contains .6 percent of organic matter, or 12 tons per acre. It is more sandy than the surface and passes into a yellow sand.

The subsoil is a yellow sand.

Treatment.—The primary consideration in the management of this type is the increasing of the organic-matter content. This may be done by turning under farm manure, crop residues, and legume crops. From 3 to 4 tons per acre of limestone may well be applied for the successful growing of clovers.

(c) TERRACE SOILS

Terrace soils have been developed on terraces or old fills in valleys. A large area in the northwestern part of Bureau county was formerly rather low and swampy. This is a broad terrace formed by deposits made by the Rock and

Green rivers during the period when the early and the late Wisconsin glaciers were melting. Large amounts of sand and gravel were carried down the flooded Rock river and were spread out over an extensive area in this part of the state forming a region known as the Winnebago swamp. This deposit is more than 200 feet deep. It is very probable that the old valley that connected the Rock river with the Illinois aided in producing the extreme width of the terrace in this region. Much of the sand that was deposited by streams was re-worked by the wind, producing the sand dunes of the county. Distinct terraces are found along Bureau creek and some of its tributaries as well as along the Illinois river. These were formed in the usual way by the partial filling up of the valley by overloaded streams which later cut down thru this fill, leaving the terrace from 20 to 50 feet above the present flood plain of the stream.

Brown Silt Loam over Gravel (1527)

Brown silt loam over gravel covers 59.65 square miles, or nearly 7 percent of the area of the county. A few small areas occur along Bureau creek and its tributaries, but most of the type is to be found in the terrace region in the west half of the county. The topography varies from flat to slightly undulating.

The surface soil, 0 to 6⅔ inches, is a brown to a dark brown granular silt loam containing from 3.3 to 7.8 percent of organic matter, with an average of 5 percent, or 50 tons per acre. In this constituent it differs but little from the brown silt loam of the upland. In physical composition the soil varies from a dark brown clayey silt loam to a silt loam with a considerable percentage of sand. Occasionally very small areas of sandy loam occur which are not large enough to be shown on the map.

The natural subsurface stratum varies from 8 to 12 inches in thickness and is a brown to a yellowish brown silt loam, containing in many cases a perceptible amount of sand.

The subsoil usually consists of a pale yellow to a drabbish or grayish yellow, slightly clayey silt, but it varies considerably. In some places the subsoil is rather sandy and may even pass thru gray-colored sand, and in others some gravel is found mixed with the finer clayey material.

Treatment.—Much of the type has been artificially drained. The strata are pervious and afford ready movement of water. Gravel or sand is not usually encountered until a depth of 55 to 60 inches has been reached. This deposit would afford good underdrainage if the water table could be lowered sufficiently.

In the management of this type, organic matter must be maintained by every available means, especially on the undulating phase. The phosphorus content is slightly lower than that of the upland brown silt loam. With respect to phosphorus the same treatment is recommended as that given for the upland brown silt loam, page 14. Applications of from 2 to 3 tons per acre of limestone will in all probability be profitable for the growing of clovers.

Brown Sandy Loam (1560)

Brown sandy loam covers an area of 27.94 square miles, or 3.24 percent of the area of the county. It is confined mostly to the northwestern part of the terrace or swamp area. In topography, it varies from flat to somewhat rolling,

the rolling character being produced by sand dunes. In the sand dune areas it usually occupies the lower lying parts.

The surface soil, 0 to 6⅔ inches, is a brown sandy loam containing about 3.1 percent, or 31 tons per acre of organic matter. It varies in texture from a somewhat fine to a coarse sand.

The natural subsurface is about 14 inches in thickness and consists of a brown to a brownish yellow sandy loam, rather variable in sand content. The organic-matter content is 1.7 percent, or 34 tons per acre, in a stratum 13⅓ inches thick.

The subsoil varies from a yellow silty sand to a yellow sand.

Treatment.—All strata are pervious to water so that underdrainage takes place readily. Natural drainage is not always sufficient and therefore it is sometimes advisable to resort to artificial drainage.

After drainage, the maintenance of organic matter and nitrogen are the most important considerations in the management of this type. These materials may be provided by utilizing the farm manure produced and supplementing this by turning under corn stalks, straw, and clovers when these are not fed on the farm. Altho the content of phosphorus is not high, fair results may be obtained without the application of phosphorus because of the large feeding range of the plant roots in this loose soil. In time, however, as the content is reduced, applications of this element will doubtless be profitable. Since all strata of this type of soil are lacking in limestone, an initial application of 3 to 4 tons per acre of this material should be made, with 1 to 2 tons every four or five years thereafter.

Black Sandy Loam (1561)

Black sandy loam is found entirely in the terrace area in the northwest part of the county. It is most abundant in the vicinity of Green river, an area which was at one time occupied by an old lake or swamp. The topography is flat with only very slight undulations, rarely more than a foot or two in height. The total area covered amounts to 8,627 acres.

The surface soil, 0 to 6⅔ inches, is a black sandy loam, usually containing sufficient clay to render the soil slightly plastic. This stratum contains in the main about 6.4 percent of organic matter, or 64 tons per acre, altho the organic-matter content varies rather widely, and small local areas contain a sufficient amount to be classed as peaty loam. Soils of this kind do not usually possess plasticity.

The natural subsurface soil, which is from 14 to 16 inches in thickness, varies from black to brown in color, and passes into a yellowish sandy material in the subsoil. In some places a perceptible amount of gravel occurs. The stratum sampled (6⅔ to 20 inches) contains 2.2 percent of organic matter, or 44 tons per acre.

The subsoil varies from a yellow, drabbish yellow, or drab, clayey sand to a yellow or drab sand. It contains .9 percent of organic matter.

Treatment.—The type generally needs drainage. Drainage and good cultivation are the principal points in its management. Spots of alkali are frequently found on which corn does not do well, and where oats lodge badly. Applications of coarse stable manure, potassium salts, or a crop of sweet clover turned

under will enable a good crop of corn to be grown. Sweet clover does especially well on soil of this character. The black sandy loam is becoming slightly acid in many places.

Dune Sand (1581)

Dune sand of the terrace occupies 6,906 acres, or 1.25 percent of the area of the county.

The surface soil, 0 to 6⅔ inches, is a light brown or grayish yellow loamy sand containing about 1.1 percent of organic matter, or 11 tons per acre.

The subsurface varies from a light brownish yellow to a yellow sand. It contains .7 percent of organic matter.

The subsoil is yellow sand.

Treatment.—In the management of this type, the principal problems are to prevent blowing and to maintain the supply of nitrogen. In this county there would be very little blowing of these sandy areas if they were left in their natural state. In many places the native vegetation has been destroyed by pasturing too closely or by cropping, thus giving the wind an opportunity to do its work. This results in the formation of "blow-outs," which are simply small areas, from a fraction of an acre to five acres in size, from which the sand is being blown. The sand from these blow-outs usually covers some better soil in the vicinity. The action of the wind may result in the ruin of the land if some protection is not given it. Wind erosion on this soil is worse than water erosion on other soils. Sand possesses very little cohesion, and it therefore is readily moved by the wind; but when organic matter is added this acts as a feeble cement that is sufficiently strong, however, to bind the particles together and thus prevent blowing.

To prevent the movement of sand by the wind, it is necessary either to have wind breaks, or to keep the soil covered with vegetation, or to incorporate organic matter. The latter two methods are really the only practical ways of preventing blowing. Every means should be used for increasing the organic matter content and for keeping a cover crop on the soil during the larger part of the year. Small grains are better adapted to accomplish this than corn.

The plants that are best adapted to sand dunes are legumes, which to a very large extent are independent of the nitrogen in the soil. It is interesting to know that a few legumes have adapted themselves to the sand to a remarkable degree. The climbing wild bean is a legume that is growing very abundantly on sand areas. It reseeds itself without any difficulty, and wheat or rye fields are soon covered with a growth of this plant after the crop has been removed. In some cases a ton or more to the acre is produced. It would seem that this plant might well be distributed over all the sand areas, especially those that are likely to blow.

Cowpeas are well adapted to growing on these sand soils. They furnish a large amount of organic matter to hold the sand and also the necessary nitrogen for growing other crops. Where wheat or rye is grown, the drill, with peas, should follow the binder. Normally they will make sufficient growth to add a considerable supply of organic matter and protect the soil during the winter. If the land is reseeded to wheat, the cowpeas may well be allowed to stand and

the wheat seeded in them, leaving the vines to protect the sand during the winter. Recent experiments show that two of the best crops for sand are sweet clover and alfalfa.

FIG. 1.—A LARGE "BLOW-OUT" WITH MANY SMALLER ONES IN THE DISTANCE
A SAND FARM MAY SOON BE RUINED BY NEGLECT

In the growing of a corn crop on sandy land, the lower blades usually die prematurely. This is commonly spoken of by farmers as "firing" and is attributed to a lack of moisture. While a deficiency of moisture may be responsible to a certain extent, the trouble is more often due to a lack of the element nitrogen. A liberal supply of organic matter, especially that from legumes, will do much to prevent firing.

In the management of a crop on sandy land, cultivation should be practiced no more than is absolutely necessary and should then be as shallow as possible. Sand is naturally well adapted to prevent moisture from evaporating, and there is no necessity for any more cultivation than is really necessary to kill the weeds. Some farmers in Michigan never cultivate their corn crop on sand soil, but instead cut out what few weeds there are with a hoe, and they succeed in raising larger crops than where cultivation is practiced.

Foresting is a practical way of conserving these sand soils. Black locust (a leguminous tree) seems to do exceptionally well on sand. One difficulty that has been experienced is that the locust tree is damaged by borers; but if it is used to start a growth and hold the sand temporarily, other trees may then be interplanted with the result that the sand will be held permanently. After the blowing of sand is once stopped, very careful treatment is required to prevent a recurrence of the trouble. Pasturing should be done very carefully, so that the grass will not be entirely destroyed.

While the acidity is not high, the sand soil is entirely devoid of limestone. For satisfactory results, therefore, an application of from 2 to 4 tons per acre of limestone is recommended, and the supply should be maintained by subsequent applications every four or five years. When potash salts can be secured

at reasonable cost, their use is likely to produce profitable results, at least temporarily, in getting under way systems of permanent improvement. This applies more especially to the level areas, which were originally sandy swamps.

As the nitrogen content is exceedingly low, successful crop production on this type of soil rests upon the building up of the supply of this element, and this can be accomplished thru the growth of legumes as recommended above.

The phosphorus content of this sand type is not high, only 780 pounds per acre of this element being present in the plowed soil, but it exists to a considerable extent in other constituents than sand grains. This is shown by some work of the United States Bureau of Soils in which two types of sandy soil, glacial sand and sandy loam, were separated into coarse and fine particles. Each grade was analyzed for phosphorus, and it was found that as an average of the two soils the fine portion was eighteen times as rich in the element phosphorus as the coarse. Under successful cropping, the limited amount of phosphorus contained in this dune sand would sooner or later become exhausted, altho field experiments might not indicate a need of phosphorus at first.

FIG. 2.—THE TRAILING WILD BEAN HOLDS THE SAND AND ADDS NITROGEN AND ORGANIC MATTER

The total supply of potassium is much smaller than is found in the more common soils. As to its availability for growing crops on sandy soils, field experiments have shown some discrepancies in results, owing probably to a variation in the condition in which the potassium exists. Definite recommendations, therefore, regarding the application of potassium to this type of soil must await the collection of more reliable information. (On swamp sands and sandy loams long exposed to leaching, potassium is often the first limiting element, especially where a fair supply of humus exists, as in the so-called "black sand.")

For an account of field experiments on sand soil see page 70 of the Supplement.

Black Mixed Loam (1550)

Black mixed loam occurs in the terrace region in the northwest part of the county, principally in Town 18 North, Range 7 East. The total area covered amounts to 2,515 acres. The topography is flat with occasional slight undulations not more than two feet in height.

The surface soil, 0 to 6⅔ inches, is a black loam, so variable in composition that it cannot be divided into distinct soil types. Small areas may be peat, others peaty loam, black clay loam, or sandy loam, and this mixed character makes it impossible to separate it into distinct types. The surface stratum contains about 10.5 percent of organic matter, or 105 tons per acre.

The natural subsurface usually varies from 14 to 18 inches in thickness, and is a black mixed loam becoming drab or drabbish yellow with depth. The organic-matter content is approximately 3.9 percent, or 78 tons per acre in a stratum twice the thickness of the surface soil.

The subsoil is variable in composition and color, but usually consists of a mixture of clay, silt, sand, and gravel. It contains about 1.2 percent of organic matter.

Treatment.—This soil is very rich in organic matter, nitrogen, and phosphorus. The first thing to be considered in the management of this type is drainage, and the pervious character of the strata enables this to be accomplished very readily where the proper outlet can be obtained. This type contains many alkali areas, the treatment of which should be the same as that recommended for the alkali spots in the black sandy loam (1561) described above.

Black Silt Loam (1525)

Black silt loam is found in the terrace area of the western part of the county, and occupies the low, undrained areas of the higher part of the terrace. The total area amounts to 3,149 acres. The topography is flat with an occasional slight undulation of a foot or two. These higher parts are frequently strongly alkaline, and require special treatment before corn and oats can be grown successfully.

The surface soil, 0 to 6⅔ inches, is a black silt loam, which varies from a clayey silt, bordering on black clay loam, to a slightly sandy phase. Occasional patches which are very high in organic matter cause the type to grade toward clayey muck. This stratum contains about 6.1 percent of organic matter, or 61 tons per acre.

The natural subsurface, which is represented by a stratum 12 to 20 inches thick, is a black silt loam varying on one hand to a black clay loam, and on the other to sandy loam. The subsurface stratum as sampled (6⅔ to 20 inches) contains about 5.9 percent of organic matter, or 118 tons per acre.

The subsoil is a blackish to drabbish yellow clayey silt or silty clay, frequently containing some pebbles and a considerable amount of sand in local areas. It contains about 2.1 percent of organic matter. In one area a bright, brownish yellow stratum about 2 or 3 inches in thickness was found in the subsoil. This material contained so much phosphorus as to cause the subsoil sample, 20 to 40 inches, to show over 33,000 pounds per acre.

Treatment.—The first requirement of this soil is drainage, and this, with good cultivation, is about all that is needed for the present.

Yellow-Gray Sandy Loam (1564)

Yellow-gray sandy loam occurs in the terrace in the northwest part of the county and covers 3,174 acres. It represents some of the higher areas, together with many sand dunes, that have been covered with finer material. The character of the soil has been somewhat modified by the growth of forests consisting principally of black oak (*Quercus marylandica*). The topography varies from flat to somewhat rolling, the latter condition being caused by sand dunes.

The surface soil, 0 to 6⅔ inches, is a yellow to grayish yellow and brownish yellow sandy loam, usually containing large amounts of sand and grading into dune sand in many places. On this type, many small areas, especially those having dune topography, could be mapped as sand, were the areas large enough. The surface stratum contains about 2.4 percent of organic matter, or 24 tons per acre.

The subsurface varies from a silty sand or even a sandy silt to pure sand, and is usually yellow in color. There is a decrease in the amount of organic matter in the subsurface, the analysis of which shows only .7 percent.

The subsoil consists of a yellow silty sand or sand.

Treatment.—The type is rather low in productiveness, due to the low organic-matter content. The best way to improve this condition is to turn under manures and all crop residues possible. The addition of limestone to the amount of 3 or 4 tons per acre will permit the growing of clover, which is so effectively used for soil renovation. Sweet clover could be used to excellent advantage on this type. The entire crop with the exception of the seed should be turned under.

Brown Fine Sandy Loam (1571)

In the northeast township of the county, there are several areas of brown fine sandy loam that aggregate 1,165 acres. This type varies in topography from flat to slightly undulating.

The surface soil, 0 to 6⅔ inches, is a brown fine sandy loam, varying on one hand to a brown silt loam, and on the other hand to a brown medium sandy loam. It contains some small areas of ordinary sandy loam that represent low dunes. The organic-matter content is about 4.4 percent, or 44 tons per acre.

The natural subsurface is represented by a stratum 8 to 12 inches thick, and is a brown fine sandy loam, usually becoming more sandy with depth until it passes into a yellow silty sand. The subsurface stratum as sampled (6⅔ to 20 inches) contains about 1.9 percent of organic matter, or 38 tons per acre.

The subsoil is a yellow to a drabbish yellow silty sand, frequently passing into almost pure medium sand.

Treatment.—After drainage, the maintenance of organic matter and nitrogen is the principal consideration in the management of this type. Applications of 3 or 4 tons per acre of limestone should be made for the successful growing of clover.

Black Clay Loam (1520)

A few areas of black clay loam are found on the upper terrace that aggregate but 422 acres. The topography is flat.

The surface soil, 0 to 6⅔ inches, is a black, plastic, granular clay loam, varying toward a black silt loam. It contains about 7.5 percent of organic matter, or 75 tons per acre.

The natural subsurface, 10 to 18 inches in thickness, is a black to a dark drab clay loam, considerably heavier than the surface. The stratum as sampled (6⅔ to 20 inches) contains about 4.2 percent of organic matter, or 84 tons per acre.

The subsoil is a heavy drab to yellow clay loam, containing about 1.5 percent of organic matter. It contains in some cases a small amount of gravel.

Treatment.—Drainage is the first requirement of this type. In spite of the heavy character of the strata, drainage takes place readily, due to the joints in the soil produced by shrinkage in times of drouth.

In this type it is doubly necessary to maintain the supply of organic matter in order to keep the soil in good physical condition and to give it easy working qualities. Limestone also must be maintained for the same purpose.

Brown-Gray Sandy Loam on Tight Clay (1568)

Brown-gray sandy loam on tight clay is scattered over a considerable area of the terrace, but not in large tracts. The total area covered by the type is 1,562 acres, or .28 percent of the entire county. For some reason a large amount of very fine material has been deposited at variable depths in this type, which has resulted in producing a tight layer thru which water passes with great difficulty. This has changed the color of the subsurface soil to a gray, and has rendered the soil less valuable. The topography of this type is generally flat.

The surface soil, 0 to 6⅔ inches, is a brown to a grayish brown sandy loam. When freshly plowed, the grayish color becomes more evident shortly after a rain. Usually the gray shows up in small areas not more than three to six rods in diameter. This stratum contains about 2.8 percent of organic matter, or 28 tons per acre. In physical composition it varies somewhat toward a brown silt loam.

The natural subsurface is represented by a layer 8 to 12 inches thick which consists of a grayish sandy silt loam that varies to a gray sandy loam. The organic-matter content of the stratum 6⅔ to 20 inches is about 1.4 percent.

The subsoil is rather variable. The tight clay is not uniform in depth, but may occur at depths ranging from 16 to 30 inches. The thickness, too, is variable. The subsoil in general is a gray to yellowish gray sand with the tight stratum consisting of a sandy clay or a clayey sand.

Treatment.—Drainage is one of the first requirements of this type of soil. The presence of the tight clay stratum in the subsoil retards drainage to such an extent that the lines of tile must be placed not more than four or five rods apart, and even closer than this would be better. Deep-rooting crops are very desirable, especially sweet clover, but it must be remembered that inoculation and plenty of limestone are needed in growing it. The deep roots penetrate the tight clay layer and will in time render it more pervious. At the same time, organic matter must be added to the soil to increase granulation. As the limestone moves downward, it too has a beneficial effect on granulation and tends to make the soil more porous. Since the soil is acid, 4 or 5 tons per acre of limestone should be applied at first with about 2 tons every four years afterward.

Yellow-Gray Silt Loam over Gravel (1536)

Yellow-gray silt loam over gravel occurs principally along the streams in the eastern and southern parts of the county as terraces from 40 to 60 feet above the present bottom land. The total area amounts to 2,118 acres. The topography varies from flat to slightly undulating, in some cases with a rather steep incline to the present flood plain. The areas occur as remnants of the former fill along Bureau creek and its branches, and also along the Illinois river.

The surface soil, 0 to 6⅔ inches, varies from a grayish yellow to a yellow silt loam, containing about 1.6 percent of organic matter, or 16 tons per acre.

The subsurface is a yellow silt loam, with approximately .6 percent of organic matter.

The subsoil is a yellow silt to a clayey silt. The gravel stratum is from 38 to 60 inches beneath the surface.

Treatment.—The drainage is good, owing to the presence of the deep subsoil gravel. The organic-matter content is very low, and every means should be used for increasing it. Limestone should be applied to permit the growing of large crops of legumes for soil improvement. In addition to these, straw, corn stalks, and all manure possible should be turned back into the soil. Phosphorus should be applied as the type is somewhat deficient in this element.

Yellow-Gray Sandy Loam on Gravel (1564.4)

Yellow-gray sandy loam on gravel covers an area of 211 acres. It is almost entirely confined to the terraces along the Illinois river.

The surface soil, 0 to 6⅔ inches, contains about 1.7 percent of organic matter or 17 tons per acre.

The subsurface is a yellow silt loam, passing into sandy and gravelly silt, the gravel beginning at from 18 to 24 inches. The subsurface contains about .5 percent of organic matter.

The subsoil is a silty gravel.

Treatment.—This type of soil needs for its improvement all the organic matter that can be economically worked into it. Besides organic matter and nitrogen it is also in need of phosphorus and limestone. Since the gravel is so near the surface, the type is not a good one to resist drouth.

Brown Sandy Loam on Gravel (1560.4)

Brown sandy loam on gravel occurs along Bureau creek and covers an area of 77 acres.

The surface soil contains about 2 percent of organic matter, or 20 tons per acre. It is a light brown sandy loam, the sand being mostly coarse.

The subsurface contains approximately 1.2 percent of organic matter.

Treatment.—The gravel is but 16 to 24 inches beneath the surface, and this renders the type a poor one to resist drouth. Its treatment should be similar to that recommended for the preceding type.

Brown-Gray Silt Loam on Tight Clay (1528)

The area of brown-gray silt loam on tight clay is very small, amounting to but 109 acres. It does not differ in character from the upland type; therefore, for recommendations the reader is referred to the discussion of this type under upland soils. (See page 19).

Gravelly Loam (1590)

There are only 109 acres of gravelly loam in the terrace. This should receive the same treatment as the upland type bearing this name. (See page 19).

(d) SWAMP AND BOTTOM-LAND SOILS

The bottom land of the Illinoisan glaciation represents the older bottom lands, while the Iowan and early Wisconsin represent the newer ones. There is but little difference between the two.

Mixed Loam (1354, 1454)

The mixed loam is found along practically all the small streams of the county, forming flood plains varying from a few rods to a mile in width. It covers a total area of 39.81 square miles, or 4.61 percent of the area of the county. Mixed loam varies widely in physical composition, including small areas of sand, sandy loam, silt loam, and even clay loam. These are usually so badly mixed that a separation is not practical. During flood times, the character of the soil may be changed entirely.

The surface soil, 0 to 6⅔ inches, consists of a mixed loam containing from 3.6 to 6.1 percent of organic matter with an average of 4.9 percent, or 49 tons per acre. The surface soil varies widely, a distance of a rod often giving entirely different kinds of soil. Small areas of peat may occur.

The subsurface, to a depth of 20 inches, is a dark soil of varying texture, containing about 3.6 percent of organic matter.

The subsoil varies from a brown to a drab or yellowish clayey silt to sandy silt. It is sufficiently pervious for good drainage.

Treatment.—No applications of plant food are advised for this type of soil, since it annually receives deposits from overflow sufficient to maintain the fertility of the soil. It usually grows good crops unless damaged by overflow or by poor drainage.

Deep Peat (1401)

Deep peat occurs mainly in the terrace region of the northwest part of the county. The total area covered is 6,400 acres, or 1.16 percent of the area of the county. Some of these peat deposits are very deep. One in Section 11, Town 16 North, Range 7 East is said to be 65 feet deep, while the area in Sections 10 and 11, Town 17 North, Range 7 East, is from 30 to 40 feet deep.

The surface soil, 0 to 6⅔ inches, consists of a brown to black, fairly well-decomposed material containing from 31 to 56 percent of organic matter with an average of 43.7 percent, or about 220 tons per acre.

The subsurface soil consists of material that is usually less decomposed than that of the surface. The samples taken contained the same percent of organic matter as the surface.

The subsoil contains, as an average, about 31 percent of organic matter.

Treatment.—The first requirement of this type is drainage. The best form of drainage, especially at first, is the open ditch. Peat, because of its loose, uncompacted condition, does not furnish a very good bed for tile. This may be remedied, however, by putting a board in the bottom of the ditch and placing the tiles on that.

Characteristic of peat, this soil is extremely rich in nitrogen, is well supplied with phosphorus, but is very deficient in potassium, as compared with ordinary fertile soils. Where thoro drainage can be provided either by open ditches or by laying tiles deep enough to secure a solid bed for them, very marked improvement can be made in the productive power of deep peat by the liberal use of potassium, which is the only deficient element. Stable manure, as well as straw and other crop residues which contain a certain amount of potassium, can be used to supply this element, altho a more economical use of the manure is made when applied to soil that can utilize the nitrogen to better advantage than does peat. Experimental results, as obtained by the Experiment Station, as well as practical experience on the part of farmers, have demonstrated that kainit and the mineral potassium compounds such as the chlorid, sulfate, or carbonate of potassium, are used on this kind of land with great profit.

For an account of field experiments on deep peat the reader is referred to page 72 of the Supplement.

Medium Peat on Clay (1402)

Medium peat on clay occurs almost entirely within the terrace region and it covers an area of 2,061 acres. The topography is usually flat.

The surface soil, 0 to 6⅔ inches, is a brown to black peat, and contains about 44 percent of organic matter.

The subsurface is a sandy or clayey material containing about 20 percent of organic matter. The upper half of the subsurface is usually peaty, and the amount of organic matter gradually diminishes until at a depth of about 20 to 25 inches it passes into drab clay or clayey sand.

The subsoil varies largely in physical composition, but is usually a drab clay or a clayey sand.

Treatment.—The first requirement of this type is drainage. Owing to the peculiar make-up of this soil its method of management may be rather variable, particularly with respect to the application of potassium. The peaty layer of the surface is very deficient in potassium while at the same time there is a large store of this element in the clay lying at varying depths below the surface. Sometimes good crops are obtained at once after drainage has been effected. Sometimes but one application of potassium is required to start production. Sometimes the first crop is poor but subsequent crops become better owing to the accumulation of potassium near the surface brought up from below by the roots of the previous crops. Sometimes the gradual mixing of the materials of the upper and lower strata thru tillage produces a good effect. Now and then farmers report great success in improving this kind of land by deep plowing or subsoiling, whereby the clayey material becomes incorporated with the peaty substance.

Therefore, just what course to pursue in improving this land will depend to a large extent upon the depth of the peaty layer, and the farmer must be guided largely by experience. If, after thoro drainage has been effected, corn fails to grow well, the indication is that potassium is needed either to supply a natural deficiency or to overcome the effects of an alkaline condition that sometimes exists in this kind of soil.

Peaty Loam (1410)

Within the terrace region a large amount of peaty loam is found, the total area being 17.07 square miles, which is about 2 percent of the area of the county.

The surface soil, 0 to 6⅔ inches, contains from 12 to 16 percent of organic matter. The mineral constituent is principally white sand.

The subsurface contains from 3.2 to 4.5 percent of organic matter, with an average of 3.8 percent.

The subsoil contains a little more than 2 percent of organic matter.

Treatment.—The first requirement of peaty loam is drainage. The types, peaty loam, (1410), black mixed loam (1450 and 1550), and black sandy loam (1461 and 1561) frequently have some areas which do not grow good crops, especially corn. The leaves of corn become striped with yellow, or turn yellow or brown. The growth is not large and the plant presents a leafy appearance due to the short joints of the stalk. These areas need potassium. It may be supplied by applying from 100 to 200 pounds per acre of potassium chlorid or potassium sulfate, or by turning under coarse manure, straw, or a green crop.

Much of the peaty loam contains spots of alkali, which are so strongly charged that grain crops will not grow. A crop of sweet clover turned under will be very beneficial on this alkali soil.

Black Clay Loam (1420)

Several small areas of black clay loam are found in the swamp region in Towns 16 and 17 North, Range 6 East. These cover a total area of 160 acres.

The surface soil, 0 to 6⅔ inches, is a black, plastic, very granular clay loam containing about 7.5 percent of organic matter, and grading in this respect toward clayey muck.

The subsurface is a black clay loam containing 4.2 percent of organic matter.

The subsoil is a dark drab clay loam containing 1.5 percent of organic matter.

Treatment.—Good drainage and good cultivation are the things necessary in the management of this type.

Black Silt Loam (1425)

Black silt loam is found in the low, swampy part in Towns 16 and 17 North, Range 6 East, occupying an area of 4,365 acres. The area is very flat and at one time was a lake or swamp.

The surface soil, 0 to 6⅔ inches, is variable in organic-matter content, but averages about 13 percent, or 130 tons per acre. In physical composition it varies from a black clayey silt to a black sandy loam with some small areas of peat or clayey muck.

The subsurface soil is a black clayey silt varying somewhat with the surface. It contains about 4.9 percent of organic matter.

The subsoil is drab to drabbish yellow in color. It contains 2.9 percent of organic matter.

Treatment.—The first requirement of this type is drainage, and after this is provided but little else is necessary other than good cultivation. Spots of alkali are found.

Deep Brown Silt Loam (1426)

Deep brown silt loam occurs only in the bottom land of the Illinois river. It covers 8,256 acres. It is flat and usually so wet and swampy that it cannot be cultivated.

The surface soil, 0 to 6⅔ inches varies from a clayey silt to a silt loam in texture, and from brown to black in color. It contains about 7.5 percent of organic matter.

The subsurface contains approximately 4.2 percent of organic matter. It becomes somewhat heavier with depth.

The subsoil varies to a greater extent than either of the other strata. In some cases peat or muck has been covered by deposits during floods, and these now form the subsoil. In one sample taken, the subsoil contained two times as much organic matter as the surface.

Treatment.—Where the land is workable good cultivation is about all that is necessary in the management of this type.

Black Mixed Loam (1450)

A number of small areas of black mixed loam occur in Town 17 North, Range 6 East, covering 422 acres.

This soil is very similar to the terrace type of the same name (1550), and should be managed in the same manner.

Black Sandy Loam (1461)

Black sandy loam is found as a broad swampy plain along the Green river and covers 5,606 acres, or about one percent of the area of the county. The area is very flat.

The surface soil is a black sandy loam containing some clay and varying from a sandy clayey silt to a sandy loam with 65 to 70 percent of sand. It contains about 9.9 percent of organic matter, or 99 tons per acre.

The subsurface soil contains 4.2 percent of organic matter, and varies somewhat the same as the surface.

The subsoil is drab in color and varies in physical composition from a sand to a clay loam, the most common being a sandy to a gravelly clay. The organic-matter content is about 1.6 percent. The subsoil frequently contains fragments of calcium carbonate.

Treatment.—Drainage and good cultivation are necessary for this type. Alkali spots are rather abundant. For treatment of alkali spots, see description of this type in the terrace (1561), page 24.

APPENDIX

EXPLANATIONS FOR INTERPRETING THE SOIL SURVEY

CLASSIFICATION OF SOILS

In order to intelligently interpret the soil maps, the reader must understand something of the method of soil classification upon which the survey is based. Without going far into details the following paragraphs are intended to furnish a brief explanation of the general plan of classification here used.

The unit in the soil survey is the soil type, and each type possesses more or less definite characteristics. The line of separation between adjoining types is usually distinct, altho sometimes one type grades into another so gradually that it is very difficult to draw the line between them. In such exceptional cases, some slight variation in the location of soil-type boundaries is unavoidable.

In establishing soil types several factors must be taken into account. These are: (1) the geological origin of the soil, whether residual, cumulose, glacial, eolial, alluvial, or colluvial; (2) the topography, or lay of the land; (3) the native vegetation, as forest or prairie grasses; (4) the depth and the character of the surface, the subsurface, and the subsoil, as to the percentages of gravel, sand, silt, clay, and organic matter which they contain, their porosity, granulation, friability, plasticity, color, etc.; (5) the natural drainage; (6) the agricultural value, based upon its natural productiveness; (7) the ultimate chemical composition and reaction.

Great Soil Areas in Illinois.—On the basis of the first of the above mentioned factors, namely, the geological origin, the state of Illinois has been divided into sixteen great soil areas with respect to their geological formation. The names of these areas are given in the following list along with their corresponding index numbers, the use of which is explained below. For the location of these geological areas, the reader is referred to the general map published in Bulletins 123 and 193.

100	*Unglaciated,* comprizing three areas, the largest being in the south end of the state
200	*Illinoisan moraines,* including the moraines of the Illinoisan glaciation
300	*Lower Illinoisan glaciation,* covering nearly the south third of the state
400	*Middle Illinoisan glaciation,* covering about a dozen counties in the west-central part of the state
500	*Upper Illinoisan glaciation,* covering about fourteen counties northwest of the middle Illinoisan glaciation
600	*Pre-Iowan glaciation,* but now believed to be part of the upper Illinoisan
700	*Iowan glaciation,* lying in the central northern end of the state
800	*Deep loess areas,* including a zone a few miles wide along the Wabash, Illinois, and Mississippi rivers
900	*Early Wisconsin moraines,* including the moraines of the early Wisconsin glaciation
1000	*Late Wisconsin moraines,* including the moraines of the late Wisconsin glaciation
1100	*Early Wisconsin glaciation,* covering the greater part of the northeast quarter of the state
1200	*Late Wisconsin glaciation,* lying in the northeast corner of the state
1300	*Old river bottom and swamp lands,* found in the older or Illinoisan glaciation
1400	*Late river bottom and swamp lands,* those of the Wisconsin and Iowan glaciations
1500	*Terraces,* formed by overloaded streams draining from the glaciers and gravel outwash plains
1600	*Lacustrine deposits,* formed by Lake Chicago or the enlarged Lake Michigan

Mechanical Composition of Soils.—The mechanical composition, or the texture, is a most important feature in characterizing a soil. The texture depends upon the relative proportions of the following physical constituents:

Organic matter: undecomposed and partially decayed vegetable material

Inorganic matter: clay, silt, fine sand, sand, gravel, stones.

Classes of Soils.—Based upon the relative proportion of the various constituents mentioned above, soils may be grouped into a number of well recognized classes. Following is a list of these classes, arranged according to their index numbers, the use of which is explained below.

Index Number Limits	Class Names
0 to 9	Peats
10 to 12	Peaty loams
13 to 14	Mucks
15 to 19	Clays
20 to 24	Clay loams
25 to 49	Silt loams
50 to 59	Loams
60 to 79	Sandy loams
80 to 89	Sands
90 to 94	Gravelly loams
95 to 97	Gravels
98	Stony loams
99	Rock outcrop

Naming and Numbering Soil Types.—The naming of soil types has been the subject of much discussion, and practice varies considerably in this matter. In this soil survey of Illinois a system of classification and naming has been adopted which is based upon the various considerations presented in the preceding paragraphs.

After texture, one of the most striking characteristics of a soil is the color. Therefore, in the naming of soils in Illinois, a combination of color and texture, together with other descriptive terms when necessary, has been adopted so that the name in itself carries a definite description of a given soil type; as for example, "gray silt loam on tight clay," or "brown silt loam over gravel." The use of the prepositions *on* and *over* serves to indicate the presence of certain substrata. When the surface soil is underlain with material such as sand, gravel, or rock, the word *over* is used if this material lies at a depth greater than 30 inches; if it is less than 30 inches, the word *on* is used.

For further identification of soil types a system of numbering, resembling somewhat the Dewey library system, has been adopted whereby each soil type is assigned a certain number. This number indicates at once the geological origin of the soil as well as its physical description. The digits of the order of hundreds represent the geological area where the soil is found, beginning at 100 with the unglaciated, and following in series in the order of the enumeration presented in the paragraph above headed *Great Soil Areas In Illinois.* The digits of the orders of units and tens represent the various kinds of soil such as are enumerated above in the list of soil classes. A modification of a soil type called a *phase* is designated in this system by a figure placed at the right of the decimal point. To illustrate the working of this numbering system, suppose a soil type bears the number 726.5. The number 7 indicates that this soil occurs in the Iowan glaciation, the 26 that it is a brown silt loam, and the .5 that rock is found less than 30 inches below the surface. These numbers are especially useful in designating small areas on the map and as a check in reading the colors.

A complete list of the soil types occurring in each county, along with their corresponding type numbers and a description of the area covered, will be found in the respective county soil reports.

SOIL SURVEY METHODS

Mapping the Soil Types.—In conducting the soil survey, the county constitutes the unit of working area. In order that the survey be thoroly truthworthy it is necessary that careful, well-trained men be employed to do the mapping. The work is prosecuted to the best advantage by working in parties of from two to four. Only such men are placed in charge of these parties as are thoroly experienced in the work and have shown themselves to be especially well qualified in training and ability.

The men must be able to keep their location exactly and to recognize the different soil types, with their principal variations and limits, and they must show these upon the maps correctly. A definite system is employed in checking up this work. As an illustration, one man will survey and map a strip 80 rods or 160 rods wide and any convenient length, while his associate will work independently on another strip adjoining this area, and if the work is correctly done the soil-type boundaries will match up on the line between the two strips.

An accurate base map for field use is absolutely necessary for soil mapping. The base maps are prepared on a scale of one inch to the mile, the official data of the original or subsequent land survey being used as a basis in their construction. Each surveyor is provided with one of these base maps, which he carries with him in the field; and the soil-type boundaries, together with the streams, roads, railroads, canals, and town sites are placed in their proper locations upon the map while the mapper is on the area. Each section, or square mile, is divided into 40-acre plots on the map, and the surveyor must inspect every ten acres and determine the type or types of soil composing it. The different types are indicated on the map by different colors, pencils for this purpose being carried in the field.

A small auger 40 inches long forms for each man an invaluable tool with which he can quickly secure samples of the different strata for inspection. An extension for making the auger 80 inches long is taken by each party, so that any peculiarity of the deeper subsoil layers may be studied. Each man carries a compass to aid in keeping directions. Distances along roads are measured by an odometer attached to the axle of the vehicle or by some other measuring device, while distances in the field away from the roads are determined by pacing, an art in which the men become expert by practice. The soil boundaries can thus be located with as high a degree of accuracy as can be indicated by pencil on the scale of one inch to the mile.

Sampling for Analysis.—After all the soil types of a county have been located and mapped, samples representative of the different types are collected for chemical analysis. For this purpose usually three strata are sampled; namely, the surface (0 to 6⅔ inches), the subsurface (6⅔ to 20 inches), and the subsoil (20 to 40 inches). These strata correspond approximately, in the common kinds of soil, to 2,000,000 pounds of dry soil per acre in the surface layer, and to two times and three times this quantity in the subsurface and the subsoil, respectively.

By this system of sampling we have represented separately three zones for plant feeding. The surface layer includes at least as much soil as is ordinarily turned with the plow. This is the part with which the farm manure, limestone, phosphate, or other fertilizer applied in soil improvement is incorporated, and which must be depended upon in large part to furnish the necessary plant food for the production of crops. Even a rich subsoil has little or no value if it lies beneath a worn-out surface, but if the fertility of the surface soil is maintained at a high point, then the strong, vigorous plants will have power to secure more plant food from the subsurface and subsoil.

PRINCIPLES OF SOIL FERTILITY

Probably no agricultural fact is more generally known by farmers and landowners than that soils differ in productive power. Even tho plowed alike and at the same time, prepared the same way, planted the same day with the same kind of seed, and cultivated alike, watered by the same rains and warmed by the same sun, nevertheless the best acre may produce twice as large a crop as the poorest acre on the same farm, if not, indeed, in the same field; and the fact should be repeated and emphasized that with the normal rainfall of Illinois the productive power of the land depends primarily upon the stock of plant food contained in the soil and upon the rate at which it is liberated, just as the success of the merchant depends primarily upon his stock of goods and the rapidity of sales. In both cases the stock of any commodity must be increased or renewed whenever the supply of such commodity becomes so depleted as to limit the success of the business, whether on the farm or in the store.

CROP REQUIREMENTS

Ten different elements of plant food are essential for the growth and formation of every plant. These elements are: *carbon, oxygen, hydrogen, nitrogen, phosphorus, sulfur, potassium, magnesium, calcium, and iron;* and they are represented by the chemical symbols: C, O, H, N, P, S, K, Mg, Ca, and Fe. Some seasons in central Illinois are sufficiently favorable to allow the production of at least 50 bushels of wheat per acre, 100 bushels of corn, 100 bushels of oats, and 4 tons of clover hay. When such crops are not produced under favorable seasonal conditions, the failure is due to unfavorable soil condition, which may

TABLE A.—PLANT FOOD IN WHEAT, CORN, OATS, AND CLOVER

Produce: Kind	Produce: Amount	Nitrogen	Phosphorus	Sulfur	Potassium	Magnesium	Calcium	Iron
		lbs.	*lbs.*	*lbs.*	*lbs.*	*lbs.*	*lbs.*	*lbs.*
Wheat, grain	1 bu.	1.42	.24	.10	.26	.08	.02	.01
Wheat straw	1 ton	10.00	1.60	2.70	18.00	1.60	3.80	.60
Corn, grain	1 bu.	1.00	.17	.08	.19	.07	.01	.01
Corn stover	1 ton	16.00	2.00	2.42	17.33	3.33	7.00	1.60
Corn cobs	1 ton	4.00	.....	.....	4.00	.....	.....	.....
Oats, grain	1 bu.	.66	.11	.06	.16	.04	.02	.01
Oat straw	1 ton	12.40	2.00	4.14	20.80	2.80	6.00	1.12
Clover seed	1 bu.	1.75	.50	.....	.75	.25	.13	.....
Clover hay	1 ton	40.00	5.00	3.28	30.00	7.75	29.25	1.00

result from poor drainage, poor physical condition, or an actual deficiency of plant food.

Table A shows the plant-food requirements of some of our most common field crops with respect to the seven elements furnished by the soil. The figures show the weight in pounds of the various elements contained in a bushel or in a ton, as the case may be. From these data the amount of any element removed from an acre of land by a crop of a given yield can easily be computed.

It needs no argument to show that the continuous removal of such quantities of plant food without provision for their replacement must result sooner or later in soil depletion.

PLANT-FOOD SUPPLY

Of the ten elements of plant food, three *(carbon, oxygen,* and *hydrogen)* are secured from air and water, and seven from the soil. *Nitrogen,* one of these seven elements obtained from the soil by all plants, may also be secured from the air by one class of plants (legumes), in case the amount liberated from the soil is insufficient; but even these plants (which include only the clovers, peas, beans, and vetches among our common agricultural plants) are dependent upon the soil for the other six elements *(phosphorus, potassium, magnesium, calcium, iron, and sulfur),* and they also utilize the soil nitrogen so far as it becomes soluble and available during their period of growth.

TABLE B.—PLANT-FOOD ELEMENTS IN MANURE, ROUGH FEEDS, AND FERTILIZERS

Material	Pounds of plant food per ton of material		
	Nitrogen	Phosphorus	Potassium
Fresh farm manure	10	2	8
Corn stover	16	2	17
Oat straw	12	2	21
Wheat straw	10	2	19
Clover hay	40	5	30
Cowpea hay	43	5	33
Alfalfa hay	50	4	24
Sweet clover (water-free basis)[1]	80	8	28
Dried blood	280	...	...
Sodium nitrate	310	...	...
Ammonium sulfate	400	...	...
Raw bone meal	80	180	...
Steamed bone meal	20	250	...
Raw rock phosphate	...	250	...
Acid phosphate	...	125	...
Potassium chlorid	...	...	850
Potassium sulfate	...	...	850
Kainit	...	...	200
Wood ashes[2]	...	10	100

[1]Young second year's growth ready to plow under as green manure.
[2]Wood ashes also contain about 1,000 pounds of lime (calcium carbonate) per ton.

The vast difference with respect to the supply of these essential plant food elements in different soils is well brought out in the data of the Illinois soil survey. For example, it has been found that the nitrogen in the surface 6⅔ inches, which represents the plowed stratum, varies in amount from 180 pounds per acre to nearly 33,000 pounds. In like manner the phosphorus content varies from about 420 pounds to 4,900 pounds, the potassium ranges from 1,530 pounds to about 58,000 pounds. Similar variations are found in all of the other essential plant food elements of the soil.

With these facts in mind it is easy to understand how a deficiency of one of these elements of plant food may become a limiting factor of crop production. When an element becomes so reduced in quantity as to become a limiting factor of production, then we must look for some outside source of supply. Table B is presented for the purpose of furnishing information regarding the quantity of plant food contained in some of the materials most commonly used as sources of plant-food supply.

LIBERATION OF PLANT FOOD

The chemical analysis of the soil gives the invoice of fertility actually present in the soil strata sampled and analyzed, but the rate of liberation is governed by many factors, some of which may be controlled by the farmer, while others are largely beyond his control. Chief among the important controllable factors which influence the liberation of plant food are limestone and decaying organic matter. Tillage also has a considerable effect in this connection.

Effect of Limestone.—Limestone corrects the acidity of the soil and thus encourages the development not only of the nitrogen-gathering bacteria which live in the nodules on the roots of clover, cowpeas, and other legumes, but also the nitrifying bacteria, which have power to transform the insoluble and unavailable organic nitrogen into soluble and available nitrate nitrogen. At the same time, the products of this decomposition have power to dissolve the minerals contained in the soil, such as potassium and magnesium, and also to dissolve the insoluble phosphate and limestone which may be applied in low-priced forms. Thus, in the conversion of sufficient organic nirogen into nitrate nitrogen for a 100-bushel crop of corn, the nitrous acid formed is alone sufficient to convert seven times as much insoluble tricalcium phosphate into soluble monocalcium phosphate as would be required to supply the phosphorus for the same crop.

Effect of Organic Matter.—Organic matter may be supplied by animal manures, consisting of the excreta of animals and usually accompanied by more or less stable litter, and by plant manures, including green-manure crops and cover crops plowed under and also crop residues such as stalks, straw, and chaff. The rate of decay of organic matter depends largely upon its age, condition, and origin, and it may be hastened by tillage. The chemical analysis shows correctly the total organic carbon, which constitutes, as a rule, but little more than half the organic matter; so that 20,000 pounds of organic carbon in the plowed soil of an acre corresponds to nearly 20 tons of organic matter. But this organic matter consists largely of the old organic residues that have accumulated during the past centuries because they were resistant to decay, and 2 tons of clover or cowpeas plowed under may have greater power to liberate plant food than the 20 tons of old, inactive organic matter. The history of the individual

farm or field must be depended upon for information concerning recent additions of active organic matter, whether in applications of farm manure, in legume crops, or in sods of old pastures.

The condition of the organic matter of the soil is indicated more or less definitely by the *ratio of carbon to nitrogen.* As an average, the fresh organic matter incorporated with soils contains about twenty times as much carbon as nitrogen, but the carbohydrates ferment and decompose much more rapidly than the nitrogenous matter; and the old resistant organic residues, such as are found in normal subsoils, commonly contain only five or six times as much carbon as nitrogen. Soils of normal physical composition, such as loam, clay loam, silt loam, and fine sandy loam, when in good productive condition, contain about twelve to fourteen times as much carbon as nitrogen in the surface soil; while in old, worn soils that are greatly in need of fresh, active, organic manures, the ratio is narrower, sometimes falling below ten of carbon to one or nitrogen. Except in newly made alluvial soils, the ratio is usually narrower in the subsurface and subsoil than in the surface stratum. Soils of cut-over or burnt-over timber lands sometimes contain so much partially decayed wood or charcoal as to destroy the value of the nitrogen-carbon ratio for the purpose indicated.

The organic matter furnishes food for bacteria, and as it decays certain decomposition products are formed, including much carbonic acid, some nitrous acid, and various organic acids, and these acting upon the soil have the power to dissolve the essential mineral plant foods, thus furnishing soluble phosphates, nitrates, and other salts of potassium, magnesium, calcium, etc., for the use of the growing crop.

Effect of Tillage.—Tillage, or cultivation, also hastens the liberation of plant food by permitting the air to enter the soil. It should be remembered, however, that tillage is wholly destructive, in that it adds nothing whatever to the soil, but always leaves it poorer, so far as plant food is concerned. Tillage should be practiced so far as is necessary to prepare a suitable seed bed for root development and also for the purpose of killing weeds, but more than this is unnecessary and unprofitable; and it is much better actually to enrich the soil by proper applications of limestone, organic matter and other fertilizing materials, and thus promote soil conditions favorable for vigorous plant growth, than to depend upon excessive cultivation to accomplish the same object at the expense of the soil.

PERMANENT SOIL IMPROVEMENT

According to the kind of soil involved, any comprehensive plan contemplating a permanent system of agriculture will need to take into account some of the following considerations.

The Application of Limestone

The Function of Limestone.—In considering the application of limestone to land it should be understood that this material functions in several different ways, and that a beneficial result may therefore be attributable to quite diverse causes: Limestone provides the plant food calcium, of which certain crops are strong feeders. It corrects acidity of the soil, thus making for some crops a much

more favorable environment as well as establishing conditions absolutely required for some of the beneficial legume bacteria. It accelerates nitrification and nitrogen fixation. It promotes sanitation of the soil by preventing the growth of certain fungus diseases, such as corn root rot. Experience indicates that it modifies directly the physical structure of some soils, frequently to their great improvement.

Thus, working in one or more of these different ways, limestone often becomes the key to the improvement of worn lands. Remarkable success has been experienced with limestone used in conjunction with sweet clover in the reclamation of abandoned hill land which had been ruined thru erosion.

Amounts to Apply.—If the soil is acid, at least 2 tons per acre of ground limestone should be applied as an initial treatment. Continue to apply limestone from time to time according to the requirement of the soil as indicated by the tests described below, or until the most favorable conditions are established for the growth of legumes, using preferably at times magnesian limestone ($CaCO_3MgCO_3$), which contains both calcium and magnesium and has slightly greater power to correct soil acidity, ton for ton, than the ordinary calcium limestone ($CaCO_3$). On strongly acid soils, or on land being prepared for alfalfa, 4 or 5 tons per acre of ground limestone may well be used for the first application.

How to Ascertain the Need for Limestone.—The need of a soil for limestone may be ascertained by applying one of the following tests for soil acidity. Along with the acidity test, a test for the presence of carbonates should be made. It should be understood that a positive test for carbonates does not guarantee the absence of acid; for it may happen, especially when the soil is near the neutral point, that positive tests for both acidity and carbonates are obtained. This condition is explained by the assumption that solid particles of calcium or magnesium carbonates form centers of alkalinity within a soil that is generally acid. Because of this fact any test made of a given soil ought to be repeated if it is to be thoroly reliable. It is also desirable to test samples from different depths. Following are the directions for making these tests:

The Litmus Paper Test for Acidity. Make a ball of fresh moist soil, break it in two, insert a piece of blue litmus paper, and press the soil firmly together again. After a few minutes examine the paper. If it has turned pink or red, soil acidity is indicated. The intensity of the color and the rapidity with which it develops indicates to some extent the amount of acidity. Needless to say the reliability of the test depends upon the quality of litmus paper used.

The Potassium Thiocyanate Test for Acidity. A more recently discovered test fo soil acidity which promises to be more satisfactory than the litmus test is made with a 4-percent solution of potassium thiocyanate in alcohol—4 grams of potassium thiocyanate in 100 cubic centimeters of 95-percent alcohol (not denatured). When a small quantity of soil shaken up in a test tube with this solution gives a red color the soil is acid and limestone should be applied. If the solution remains colorless the soil is not acid. The conditions for a prompt reaction require a temperature that is comfortably warm.

The Hydrochloric Acid Test for Carbonates. Make a shallow cup of a ball of soil and pour into it a few drops of concentrated hydrochloric acid. If carbonates are present they are decomposed with the liberation of carbon dioxid, which appears as gas bubbles, producing foaming or effervescence. With much carbonate present the action is lively, but with mere traces of it the bubbles are given off slowly. If no carbonate, or very little, is indicated by the test, then it is advisable to apply limestone.

The Nitrogen Problem

Nitrogen presents the greatest practical soil problem in American agriculture. Four important reasons for this are: its increasing deficiency in most soils; its cost when purchased on the open market; its removal in large amounts by crops; and its loss from soils thru leaching. Nitrogen costs from four to

five times as much per pound as phosphorus. A 100-bushel crop of corn requires 150 pounds of nitrogen for its growth, but only 23 pounds of phosphorus. The loss of nitrogen from soils may vary from a few pounds to over one hundred pounds per acre, depending upon the treatment of the soil, the distribution of rainfall, and the protection afforded by growing crops.

An inexhaustible supply of nitrogen is present in the air. Above each acre of the earth's surface there are about sixty-nine million pounds of atmospheric nitrogen. The nitrogen above one square mile weighs twenty million tons, an amount sufficient to supply the entire world for four or five decades. This large supply of nitrogen in the air is the one to which the world must eventually turn.

There are two methods of collecting the inert nitrogen gas of the air and combining it into compounds that will furnish products for agricultural uses. *These are the chemical and the biological fixation of the atmospheric nitrogen.* Farmers have at their command one of these methods. By growing inoculated legumes, nitrogen may be obtained from the air, and by plowing under more than the roots of those legumes, nitrogen may be added to the soil.

Inasmuch as legumes are worth growing for feed and seed as well as for nitrate production, a considerable portion of the nitrogen thus gained may be considered a by-product. Because of that fact, it is questionable whether the chemical fixation of nitrogen, the possibilities of which now represent numerous compounds, will ever be able to replace the simple method of obtaining atmospheric nitrogen by growing inoculated legumes.

For easy figuring it may well be kept in mind that the following amounts of nitrogen are required for the produce named:

1 bushel of oats (grain and straw) requires 1 pound of nitrogen.
1 bushel of corn (grain and stalks) requires 1½ pounds of nitrogen.
1 bushel of wheat (grain and straw) requires 2 pounds of nitrogen.
1 ton of timothy requires 24 pounds of nitrogen.
1 ton of clover contains 40 pounds of nitrogen.
1 ton of cowpeas contains 43 pounds of nitrogen.
1 ton of alfalfa contains 50 pounds of nitrogen.
1 ton of average manure contains 10 pounds of nitrogen.
1 ton of young sweet clover, at about the stage of growth when it is plowed under as green manure, contains, on water-free basis, 80 pounds of nitrogen.

The roots of clover contain about half as much nitrogen as the tops, and the roots of cowpeas contain about one-tenth as much as the tops. Soils of moderate productive power will furnish as much nitrogen to clover (and two or three times as much to cowpeas) as will be left in the roots and stubble. In grain crops, such as wheat, corn, and oats, about two-thirds of the nitrogen is contained in the grain and one-third in the straw or stalks.

The Phosphorus Problem

The element phosphorus is an indispensable constituent of every living cell. It is intimately connected with the life processes of both plants and animals, the nuclear material of the cells being especially rich in this element.

The phosphorus content of a soil varies according to its origin and the kind of farming practiced. Even virgin soils are found that are deficient in phosphorus.

On all lands deficient in phosphorus (except on those susceptible to serious erosion by surface washing or gullying) that element should be applied in considerably larger amounts than are required to meet the actual needs of the crops desired to be produced. The abundant information thus far secured shows positively that fine-ground natural rock phosphate can be used successfully and very profitably, and clearly indicates that this material will be the most economical form of phosphorus to use in all ordinary systems of permanent, profitable soil improvement. The first application may well be one ton per acre, and subsequently about one-half ton per acre every four or five years should be applied, at least until the phosphorus content of the plowed soil reaches 2,000 pounds per acre, which may require a total application of from 3 to 5 or 6 tons per acre of raw phosphate containing 12½ percent of the element phosphorus.

Steamed bone meal and even acid phosphate may be used in emergencies, but it should always be kept in mind that a pound of phosphorus delivered in Illinois in the form of raw phosphate (direct from the mine in carload lots), is much cheaper than the same amount in steamed bone meal or in acid phosphate, both of which cost too much per ton to permit their common purchase by farmers in carload lots, which is not the case with raw phosphate. Landowners should bear in mind the fact that phosphorus additions to the soil in amounts above the immediate crop requirements represent a permanent investment, since this element is not readily lost in the drainage water as in the case of nitrogen. It is removed from the farm thru the sale of crops, milk, and animals.

Phosphate may be applied at any time during a rotation, but it is applied to the best advantage either preceding a crop of clover, which plant seems to possess an unusual power for assimilating raw phosphate, or else at a time when it can be plowed under with some form of organic matter such as animal manure or green manure, the decay of which serves to liberate the phosphorus from its insoluble condition in the rock. It is important that the fine-ground rock phosphate be intimately mixed with the organic material as it is plowed under.

The Potassium Problem

Normal soils, in which clay and silt form a considerable part of the constituency, are well stocked with potassium, altho it exists largely in insoluble form. Such soils as sands and peats, however, are likely to be low in this element. On such soils this deficiency may be supplied by the application of some potassium salt, such as potassium sulfate, potassium chlorid, kainit, or other potassium compound, and in many instances this is done at great profit.

From all the facts at hand it seems, so far as our great areas of normal soils are concerned, that the potassium problem is not one of addition but of liberation. The Rothamsted records, which represent the oldest soil experiment fields in the world, show that for many years other soluble salts have practically the same power as potassium to increase crop yield in the absence of sufficient decaying organic matter. Whether this action relates to supplying or liberating potassium for its own sake, or to the power of the soluble salt to increase the availability of phosphorus or other elements, is not known, but where much

potassium is removed, as in the entire crops at Rothamsted, with no return of organic residues, probably the soluble salt functions in both ways.

Further evidence on this matter is furnished by the Illinois experiment field at Fairfield, where potassium sulfate has been compared with kainit both with and without the addition of organic matter in the form of stable manure. Both sulfate and kainit produced a substantial increase in the yield of corn but the cheaper salt, kainit, was just as effective as the potassium sulfate, and returned some financial profit. Manure alone gave an increase similar to that produced by the potassium salts, but the salts added to the manure gave very little increase over that produced by the manure alone. This is explained in part perhaps because the potassium removed in the crops is mostly returned in the manure if properly cared for, and perhaps in larger part because the decaying organic matter helps to liberate and hold in solution other plant-food elements, especially phosphorus.

In laboratory experiments at the Illinois Experiment Station, it has been shown that potassium salts and most other soluble salts increase the solubility of the phosphorus in soil and in rock phosphate; also that the addition of glucose with rock phosphate in pot-culture experiments increases the availability of the phosphorus, as measured by plant growth, altho the glucose consists only of carbon, hydrogen, and oxygen, and thus contains no plant food of value.

In considering the conservation of potassium on the farm it should be remembered that in average live-stock farming the animals destroy two-thirds of the organic matter and retain one-fourth of the nitrogen and phosphorus from the food they consume, but that they retain less than one-tenth of the potassium; so that the actual loss of potassium in the products sold from the farm, either in grain farming or in live-stock farming, is negligible on land containing 25,000 pounds or more of potassium in the surface 6⅔ inches.

The Calcium and Magnesium Problem

When measured by the actual crop requirements for plant food, magnesium and calcium are more limited in some Illinois soils than potassium. But with these elements we must also consider the loss by leaching.

Doctor Edward Bartow and associates, of the Illinois State Water Survey, have shown that as an average of 90 analyses of Illinois well-waters drawn chiefly from glacial sands, gravels, or till, 3 million pounds of water (about the average annual drainage per acre for Illinois) contained 11 pounds of potassium, 130 of magnesium, and 330 of calcium. These figures are very significant, and it may be stated that if the plowed soil is well supplied with the carbonates of magnesium and calcium, then a very considerable proportion of these amounts will be leached from that stratum. Thus the loss of calcium from the plowed soil of an acre at Rothamsted, England, where the soil contains plenty of limestone, has averaged more than 300 pounds a year as determined by analyzing the soil in 1865 and again in 1905. And practically the same amount of calcium was found by analyzing the Rothamsted drainage waters.

Common limestone, which is calcium carbonate ($CaCO_3$), contains, when pure, 40 percent of calcium, so that 800 pounds of limestone is equivalent to 320 pounds of calcium. Where 10 tons per acre of ground limestone was applied at Edgewood, Illinois, the average annual loss during the next ten

years amounted to 790 pounds per acre. The definite data from careful investigations seems to be ample to justify the conclusion that where limestone is needed at least 2 tons per acre should be applied every four or five years.

It is of interest to note that thirty crops of clover of 4 tons each would require 3,510 pounds of calcium, while the most common prairie land of southern Illinois contains only 3,420 pounds of total calcium in the plowed soil of an acre. Thus limestone has a positive value on some soils for the plant food which it supplies, in addition to its value in correcting soil acidity and in improving the physical condition of the soil. Ordinary limestone (abundant in the southern and western parts of the state) contains nearly 800 pounds of calcium per ton; while a good grade of dolomitic limestone (the more common limestone of northern Illinois) contains about 400 pounds of calcium and 300 pounds of magnesium per ton. Both of these elements are furnished in readily available form in ground dolomitic limestone.

The Sulfur Question

In considering the relation of sulfur in a permanent system of soil fertility it is important to understand something of the cycle of transformations that this element undergoes in nature. Briefly stated this is as follows:

Sulfur exists in the soil in both organic and inorganic forms, the former being gradually converted to the latter form thru bacterial action. In this inorganic form sulfur is taken up by plants which in their physiological processes change it once more into an organic form as a constituent of protein. When these plant proteins are consumed by animals, the sulfur becomes a part of the animal protein. When these plant and animal proteins are decomposed, either thru bacterial action, or thru combustion, the sulfur passes into the atmosphere or into the soil solution in the form of sulfur dioxid gas. This gas unites with oxygen and water to form sulfuric acid, which is readily washed back into the soil by the rain, thus completing the cycle, from soil—to plants and animals—to air—to soil.

In this way sulfur becomes largely a self-renewing element of the soil, altho there is a considerable loss from the soil by leaching. Observations taken at the Illinois Agricultural Experiment Station show that 40 pounds of sulfur per acre are brought into the soil thru the annual rainfall. With a fair stock of surfur, such as exists in our common types of soil, and an annual return, which of itself would more than suffice for the needs of maximum crops, the maintenance of an adequate sulfur supply presents little reason at present for serious concern. There are regions, however, where the natural stock of sulfur in the soil is not nearly so high and where the amount returned thru rainfall is small. Under such circumstances sulfur soon becomes a limiting element of crop production, and it will be necessary sooner or later to introduce this substance from some outside source. Investigation is now under way to determine to what extent this situation may apply to conditions in Illinois.

Physical Improvement of Soils

In the management of most soil types, one very important thing, aside from proper fertilization, tillage, and drainage, is to keep the soil in good physical condition, or good tilth. The constituent most important for this purpose is

organic matter. Organic matter in producing good tilth helps to control washing of soil on rolling land, raises the temperature of drained soil, increases the moisture-holding capacity of the soil, retards capillary rise and consequently loss of moisture by surface evaporation, and helps to overcome the tendency of some soils to run together badly.

The physical effect of organic matter is to produce a granulation or mellowness, by cementing the fine soil particles into crumbs or grains about as large as grains of sand, which produces a condition very favorable for tillage, percolation of rainfall, and the development of plant roots.

Organic matter is being destroyed during a large part of the year and the nitrates produced in its decomposition are used for plant growth. Altho this decomposition is necessary, it nevertheless reduces the amount of organic matter, and provision must therefore be made for maintaining the supply. The practical way to do this is to turn under the farm manure, straw, corn stalks, weeds, and all or part of the legumes produced on the farm. The amount of legumes needed depends upon the character of the soil. There are farms, especially grain farms, in nearly every community where all legumes could be turned under for several years to good advantage.

Manure should be spread upon the land as soon as possible after it is produced, for if it is allowed to lie in the barnyard several months as is so often the case, from one-third to two-thirds of the organic matter will be lost.

Straw and corn stalks should be turned under, and not burned. Probably no form of organic matter acts more beneficially in producing good tilth than corn stalks. It is true, they decay rather slowly, but it is also true that their durability in the soil is exactly what is needed in the production of good tilth. Furthermore, the nitrogen in a ton of corn stalks is one and one-half times that of a ton of manure, and a ton of dry corn stalks incorporated in the soil will ultimately furnish as much humus as four tons of average farm manure. When burned, however, both the humus-making material and the nitrogen are lost to the soil.

It is a common practice in the corn belt to pasture the corn stalks during the winter and often rather late in the spring after the frost is out of the ground. This tramping by stock sometimes puts the soil in bad condition for working. It becomes partially puddled and will be cloddy as a result. If tramped too late in the spring, the natural agencies of freezing and thawing and wetting and drying, with the aid of ordinary tillage, fail to produce good tilth before the crop is planted. Whether the crop is corn or oats, it necessarily suffers, and if the season is dry, much damage may be done. If the field is put in corn, a poor stand is likely to result, and if put in oats, the soil is so compact as to be unfavorable for their growth. Sometimes the soil is worked when too wet. This also produces a partial puddling which is unfavorable to physical, chemical, and biological processes. The bad effect will be greater if cropping has reduced the organic matter below the amount necessary to maintain good tilth.

Systems of Crop Rotations

In a program of permanent soil improvement one should adopt at the outset a good rotation of crops, including a liberal use of legumes, in order to increase the organic matter of the soil either by plowing under the legume crops and

other crop residues (straw and corn stalks), or by using for feed and bedding practically all the crops raised and returning the manure to the land with the least possible loss. No one can say in advance for every particular case what will prove to be the best rotation of crops, because of variation in farms and farmers and in prices for produce.

Following are a few suggested rotations, applicable to the corn belt, which may serve as models or outlines to be modified according to special circumstances.

Six-Year Rotations

First year —Corn
Second year —Corn
Third year —Wheat or oats (with clover or clover and grass)
Fourth year —Clover, or clover and grass
Fifth year —Wheat (with clover) or grass and clover
Sixth year —Clover, or clover and grass

Of course there should be as many fields as there are years in the rotation. In grain farming, with small grain grown the third and fifth years, most of the unsalable products should be returned to the soil, and the clover may be clipped and left on the land or returned after threshing out the seed (only the clover seed being sold the fourth and sixth years); or, in live-stock farming, the field may be used three years for timothy and clover pasture and meadow if desired. The system may be reduced to a five-year rotation by cutting out either the second or the sixth year, and to a four-year system by omitting the fifth and sixth years, as indicated below.

Five-Year Rotations

First year —Corn
Second year —Wheat or oats (with clover, or clover and grass)
Third year —Clover, or clover and grass
Fourth year —Wheat (with clover), or clover and grass
Fifth year —Clover, or clover and grass

First year —Corn
Second year —Corn
Third year —Wheat or oats (with clover, or clover and grass)
Fourth year —Clover, or clover and grass
Fifth year —Wheat (with clover)

First year —Corn
Second year —Cowpeas or soybeans
Third year —Wheat (with clover)
Fourth year —Clover
Fifth year —Wheat (with clover)

The last rotation mentioned above allows legumes to be seeded four times. Alfalfa may be grown on a sixth field for five or six years in the combination rotation, alternating between two fields every five years, or rotating over all the fields if moved every six years.

Four-Year Rotations

First year —Wheat (with clover)
Second year —Corn
Third year —Oats (with clover)
Fourth year —Clover

First year —Corn
Second year —Corn
Third year —Wheat or oats (with clover)
Fourth year —Clover

First year —Corn
Second year —Wheat or oats (with colver)
Third year —Clover
Fourth year —Wheat (with clover)

First year —Wheat (with clover)
Second year —Clover
Third year —Corn
Fourth year —Oats (with clover)

First year —Corn
Second year —Cowpeas or soybeans
Third year —Wheat (with clover)
Fourth year —Clover

Alfalfa may be grown on a fifth field for four or eight years, which is to be alternated with one of the four; or the alfalfa may be moved every five years and thus rotated over all five fields every twenty-five years.

Three-Year Rotations

First year —Corn
Second year —Oats or wheat (with clover)
Third year —Clover

First year —Wheat (with clover)
Second year —Corn
Third year —Cowpeas or soybeans

By allowing the clover, in the last rotation mentioned, to grow in the spring before preparing the land for corn, we have provided a system in which legumes grow on every acre every year. This is likewise true of the following suggested two-year system:

Two-Year Rotation

First year —Oats or wheat (with sweet clover)
Second year —Corn

Altho in this two-year rotation either oats or wheat is suggested, as a matter of fact, by dividing the land devoted to small grain, both of these crops can be grown simultaneously, thus providing a three-crop system in a two-year cycle.

It should be understood that in all of the above suggested cropping systems it may be desirable in some cases to substitute rye for the wheat or oats. In all of these proposed rotations the word *clover* is used in a general sense to designate either red clover, alsike clover, or sweet clover. The value of sweet clover especially as a green manure for building up depleted soils, as well as a pasture and hay crop, is becoming thoroly established, and its importance in a crop-rotation program may well be emphasized.

SUPPLEMENT: EXPERIMENT FIELD DATA

(Results from Experiment Fields Representing the More Important Types of Soil Occurring in Bureau County)

In the earlier reports of this series it was the practice to incorporate in the body of the report the results of certain experiment fields, for the purpose of illustrating the possibilities of improving the soil of various types. The information carried by such data must, naturally, be considered more or less tentative. As the fields grow older new facts develop, which in some instances may call for the modification of former recommendations. It has therefore seemed desirable to separate this experiment field data from the more permanent information of the soil survey, and embody the same in the form of a supplement to the soil report proper, thus providing a convenient arrangement for possible future revisions as further data accumulate.

The University of Illinois has conducted altogether about fifty soil experiment fields in different sections of the state and on various types of soil. Altho some of these fields have been discontinued, the large majority are still in operation. It is the present purpose to report the summarized results from certain of these fields which are representative of the types of soil described in the accompanying soil report.

A few general explanations at this point, which apply to all the fields, will relieve the necessity of numerous repetitions in the following pages.

These fields vary in size from less than two acres up to 40 acres or more. They are laid off into series of plots and each series is occupied by one kind of crop. Usually there are several series so that a crop rotation can be carried on with every crop represented every year.

Farming Systems

On many of the fields the treatment provides for two distinct systems of farming, live-stock and grain farming. *In the live-stock system,* stable manure is used to furnish organic matter and nitrogen. The amount applied to a plot is based upon the amount that can be produced from crops raised on that plot.

In the grain system no animal manure is used. The organic matter and nitrogen are applied in form of plant manures, including all the plant residues produced, such as corn stalks, straw from wheat, oats, clover, etc., along with leguminous catch crops plowed under. It is the plan in this latter system to remove from the land only the grain and seed produced, except in the case of alfalfa, that crop being harvested for hay the same as in the live-stock system.

Rotations

Crops which are of interest in the respective localities are grown in definite rotations, and on most of the fields provision is made so that every crop in the rotation is represented every year. The most common rotation used is wheat, corn, oats, and clover; and often these crops are accompanied by alfalfa growing on a fifth series. In the grain system a legume catch crop, usually sweet clover, is included, which is seeded on the young wheat in the spring and plowed under in the fall or in the following spring in preparation for corn. In the event of clover failure, soybeans are substituted.

Soil Treatment

The treatment applied to the plots has, for the most part, been standardized according to a definite system, altho deviations from this system occur now and then, particularly in the older fields.

Following is a brief explanation of this standard system of treatment.

Animal Manures.—Animal manures, consisting of excreta from animals, with stable litter, are spread upon the respective plots in amounts proportionate to previous crop yields, the applications being made in the preparation for corn.

Plant Manures.—All crop residues produced on the land, such as stalks, straw, and chaff, are returned to the soil, and in addition a green-manure crop of sweet clover is seeded in small grains to be plowed under in preparation for corn. (On plots where limestone is lacking the sweet clover seldom survives.) This practice is designated as the *residues system.*

Mineral Manures.—The yearly acre-rates of application are: for limestone, 1,000 pounds; for raw rock phosphate, 500 pounds; and for potassium, the equivalent of 200 pounds of kainit. The initial application of limestone is usually 4 tons per acre.

Explanation of Symbols Used

0 = Untreated land or check plots
M = Manure (animal)
R = Residues (from crops, and includes legumes used as green manure)
L = Limestone
P = Phosphorus
K = Potassium (usually in the form of kainit)
N = Nitrogen (usually in the form contained in dried blood)
( ) = Parentheses enclosing figures signify tons of hay, as distinguished from bushels of seed

In discussions of this sort of data, financial profits or losses based upon assigned market values are frequently considered. However, in view of the erratic fluctuations in market values—especially in the past few years—it seems futile to attempt to set any prices for this purpose that are at all satisfactory. The yields are therefore presented with the thought that with these figures at hand the financial returns from a given practice can readily be computed upon the basis of any set of market values that the reader may choose to apply.

BROWN SILT LOAM

Several experiment fields have been conducted on brown silt loam soil at various locations in Illinois. Those located at the University have been in operation the longest and they serve well to illustrate the principles involved in the maintenance and improvement of this type of soil.

The Morrow Plots

It happens that the oldest soil experiment field in the United States is located on typical brown silt loam of the early Wisconsin glaciation, on the campus of the University of Illinois. This field was started in 1879 by George E. Morrow, who for many years was Professor of Agriculture, and these plots are known as the Morrow plots.

TABLE 1.—URBANA FIELD, MORROW PLOTS: BROWN SILT LOAM; PRAIRIE; EARLY WISCONSIN GLACIATION

Crop Yields in Soil Experiments—Bushels or (tons) per acre

Years	Soil treatment applied	Corn every year	Two-year rotation		Three-year rotation		
		Corn	Corn	Oats	Corn	Oats	Clover
1879–87	None.......	....	....	....	....	....	....
1888	None.......	54.3	49.5	....	....	48.6	....
1889	None.......	43.2	....	37.4	....	....	(4.04)
1890	None.......	48.7	54.3	....	....	....	(1.51)
1891	None.......	28.6	33.2	....	....	....	(1.46)
1892	None.......	33.1	....	37.2	70.2	....	....
1893	None.......	21.7	29.6	....	34.1	....	....
1894	None.......	34.8	....	57.2	....	65.1	....
1895	None.......	42.2	41.6	....	....	22.2	....
1896	None.......	62.3	....	34.5	....	....	....
1897	None.......	40.1	47.0	....	....	....	....
1898	None.......	18.1	....	....	....	....	....
1899	None.......	50.1	44.4	....	53.5	....	....
1900	None.......	48.0	....	41.5	....	....	....
1901	None.......	23.7	33.7	....	34.3	....	....
1902	None.......	60.2	....	56.3	....	54.6	....
1903	None.......	26.0	35.9	....	....	....	(1.11)
1904	None.......	21.5	....	17.5	55.3	....	....
1904	MLP.......	17.1	....	25.3	72.7	....	....
1905	None.......	24.8	50.0	....	....	42.3	....
1905	MLP.......	31.4	44.9	....	....	50.6	....
1906	None.......	27.1	....	34.7	....	....	(1.42)[1]
1906	MLP.......	35.8	....	52.4	....	....	(1.74)[1]
1907	None.......	29.0	47.8	....	80.5	....	....
1907	MLP.......	48.7	87.6	....	93.6	....	....
1908	None.......	13.4	....	32.9	....	40.0	....
1908	MLP.......	28.0	....	45.0	....	44.4	....
1909	None.......	26.6	33.0	....	....	....	(.65)[2]
1909	MLP.......	31.6	64.8	....	....	....	(1.73)[3]
1910	None.......	35.9	....	33.8	58.6	....	....
1910	MLP.......	54.6	....	59.4	83.3	....	....
1911	None.......	21.9	28.6	....	....	20.6	....
1911	MLP.......	31.5	46.3	....	....	38.0	....
1912	None.......	43.2	....	55.0	....	....	16.3[1]
1912	MLP.......	64.2	....	81.0	....	....	20.0[1]
1913	None.......	19.4	29.2	....	33.8	....	....
1913	MLP.......	32.0	25.0	....	47.8	....	....
1914	None.......	31.6	....	33.6	....	39.6	....
1914	MLP.......	39.4	....	58.2	....	60.4	....
1915	None.......	40.0	49.0	....	....	....	24.2[1]
1915	MLP.......	66.0	81.2	....	....	....	27.1[1]
1916	None.......	11.2	....	37.5	27.8	....	....
1916	MLP.......	10.8	....	64.7	40.6	....	....
1917	None.......	40.0	48.4	....	....	68.4	....
1917	MLP.......	78.0	81.4	....	....	86.9	....
1918	None.......	13.6	....	27.2	....	....	(2.58)
1918	MLP.......	32.6	....	59.3	....	....	(4.04)
1919	None.......	24.0	30.8	....	52.2	....	....
1919	MLP.......	43.4	66.2	....	70.8	....	....
1920	None.......	28.2	....	37.2	....	52.2	....
1920	MLP.......	54.4	....	51.6	....	69.7	....

[1]Soybeans.
[2]In addition to the hay, .64 bushel of seed was harvested.
[3]In addition to the hay, 1.17 bushels of seed were harvested.

TABLE 2.—URBANA FIELD, MORROW PLOTS: GENERAL SUMMARY
Bushels or (tons) per acre

Years	Soil treatment applied	Corn every year	Two-year rotation		Three-year rotation		
			Corn	Oats	Corn	Oats	Clover
		16 crops	*9 crops*	*8 crops*	*4 crops*	*4 crops*	*4 crops*
1888 to 1903	None	39.7	41.0	44.0	48.0	47.6	(2.03)
		17 crops	*8 crops*	*9 crops*	*6 crops*	*6 crops*	*3 crops*
1904 to 1920	None	26.6	39.6	34.4	51.4	43.9	(1.55)[1]
	MLP	41.1	62.2	55.2	68.1	58.3	(2.50)[1]

[1]One crop of soybean hay.

The Morrow series now consists of three plots divided into halves and the halves are subdivided into quarters. On one plot corn is grown continuously; on the second corn and oats are grown in rotation; and on the third, corn, oats, and clover are rotated. The north half of each plot has had no fertilizing material applied from the beginning of the experiments, while the south half has been treated since 1904, receiving standard applications of farm manure with cover crops grown in the one-crop and two-crop systems. Phosphorus has been applied in two different forms: rock phosphate to the southwest quarter at the rate of 600 pounds, and steamed bone meal to the southeast quarter at the rate of 200 pounds per acre per year up to 1919, when the rock phosphate was increased sufficiently to bring up the total amount applied to four times the quantity of bone meal applied. At the same time the rate of subsequent application of both forms of phosphorus was reduced to one-fourth the quantity, or to 200 pounds of rock phosphate and 50 pounds of bone meal per acre per year. In 1904 ground limestone was applied at the rate of 1,700 pounds per acre to the south half of each plot, and in 1918 a further application was made at the rate of 5 tons per acre with the intention of standardizing the application to the rate of 1,000 pounds of limestone per acre per year.

FIG. 1.—CORN ON THE MORROW PLOTS IN 1910

Table 1 gives the yearly records of the crop yields, and Table 2 presents the same in summarized form.

Summarizing the data from these Morrow plots into two periods with the second period beginning in 1904 when the treatment began on the half-plots, some interesting comparisons may be made. In the first place we find in the continuous corn plot a marked decrease in the second period in the average yield of corn, amounting to one-third of the crop. In the two-year rotation there is a decrease in both corn and oats production, while the averages for the three-year system show an increase in corn yield and decreases in oats and clover. Unfortunately the numbers of crops included in these last averages are too small to warrant positive conclusions.

The increase brought about by soil treatment stands out in all cases, showing the possibility not only of restoring but also of greatly improving the productive power of this land that has been so abused by continuous cropping without fertilization.

The Davenport Plots

Another set of plots on the University campus at Urbana, forming a more extensive series than the Morrow plots, but of more recent origin, are the Davenport plots. Here each crop in the rotation is represented every year. These plots were laid out in 1895, but special soil treatment was not begun until 1901. They now comprize five series of ten plots each, and each series constitutes a "field" in a crop rotation system.

From 1901 to 1911 three of the series were in a three-year rotation system of corn, oats, and clover, while the remaining two series rotated in corn and oats. In 1911 these two systems were combined into a five-series field, with a crop rotation of wheat, corn, oats, and clover, with alfalfa on a fifth field. The alfalfa occupies one series during a rotation of the other four crops, shifting to another series in the fifth year, thus completing the cycle of all series in twenty-five years.

The soil treatment applied to these plots has been as follows:

Legume cover crops were seeded in the corn at the last cultivation on Plots 2, 4, 6, and 8, from 1902 to 1907, but the growth was small and the effect, if any, was to decrease the returns from the regular crops. Crop residues (**R**) have been returned to these same plots since 1907. These consist of stalks and straw, and all legumes except alfalfa hay and the seed of clover and soybeans. Beginning in 1918 a modification of the practice was made in that one cutting of the red clover crop is harvested as hay. In conjunction with these residues a catch crop of sweet clover grown with the wheat is plowed under.

Manure (**M**) was applied preceding corn, at the rate of 2 tons per acre per year in 1905, 1906, and 1907; subsequently as many tons have been applied as there have been tons of air-dry produce harvested from the respective plots.

Lime (**L**) was applied on Plots 4 to 10 at the rate per acre of 250 pounds of air-slaked lime in 1902, and 600 pounds of limestone in 1903. No further application was made until 1911, when the system of cropping was changed. Since that time applications of limestone have been made at the rate of one-half ton per acre per year.

Phosphorus (**P**) was applied on Plots 6 to 9 at the rate of 25 pounds per acre per annum in 200 pounds of steamed bone meal; but beginning with 1908 rock phosphate at the rate of 600 pounds per acre per annum was substi-

TABLE 3.—URBANA FIELD, DAVENPORT PLOTS: BROWN SILT LOAM, PRAIRIE; EARLY WISCONSIN GLACIATION

Ten-Year Average Annual Yields—Bushels or (tons) per acre
1911-1920

Serial plot No.	Soil treatment applied	Corn	Oats	Wheat	Clover 5 crops	Soybeans 5 crops	Alfalfa
1	0	55.6	50.5	26.0	(2.42)	(1.47)	(2.43)
2	R	57.1	52.3	28.7	1.47[1]	19.8	(2.46)
3	M	66.3	61.9	28.2	(2.56)	(1.62)	(2.52)
4	RL	64.8	55.6	31.4	1.61[1]	20.3	(2.72)
5	ML	69.6	64.1	32.8	(2.90)	(1.67)	(3.03)
6	RLP	71.5	69.8	43.0	2.29[1]	23.5	(3.69)
7	MLP	73.0	68.6	40.0	(3.52)	(1.97)	(3.76)
8	RLPK	70.9	72.5	40.7	1.79[1]	25.5	(3.77)
9	MLPK	70.2	72.0	39.2	(3.40)	(2.20)	(3.73)
10	Mx5LPx5	65.9	71.4	40.6	(3.31)	(2.22)	(3.77)

[1]In addition to the clover seed, a crop of hay was harvested one year on Plots 2, 4, 6, and 8, yielding 2.38, 2.20, 2.54, and 2.39 tons, respectively.

tuted for the bone meal on one-half of each of these plots. These applications continued until 1918 when adjustments were begun, first to make the rate of application of rock phosphate four times that of the bone meal, and finally to reduce the amounts of these materials to 200 pounds of rock phosphate and 50 pounds of bone meal per acre per annum. The usual practice has been to apply and plow under at one time all phosphorus and potassium required for the rotation.

Potassium (**K** = kalium) has been applied on Plots 8 and 9 in connection with the bone meal and rock phosphate, at the yearly rate of 42 pounds per acre, and mainly as potassium sulfate.

On Plot 10 about five times as much manure and phosphorus are applied as on the other plots, but this "extra heavy" treatment was not begun until 1906, only the usual lime, phosphorus, and potassium having been applied in previous years. The purpose in making these heavy applications is to try to determine the climatic possibilities in crop yields by removing the limitations of inadequate fertility.

It will be observed that the applications described above provide for the two rather distinct systems of farming already described. *The grain system,* in which animal manure is not produced and where the organic matter is provided by the direct return to the soil of all crop residues, is exemplified in Plots 2, 4, 6, and 8; and the *live-stock system,* in which farm manure is utilized for soil enrichment, is represented in Plots 3, 5, 7, and 9.

Table 3 shows a summary of the results obtained on the Davenport plots beginning with the year 1911, when the present cropping system was introduced.

When used in conjunction with phosphorus the crop residues and the manure appear about equally effective; but where phosphorus is not applied, the manure has been decidedly more effective, under the conditions of the experiment. It should be observed, however, in this connection, that the plowing under of clover is a very essential feature of the residues system, and that, as a matter of fact, there were five clover failures, when soybeans were substituted, during the ten years. Perhaps with a more reliable biennial legume than red clover, the results would have been more favorable for this system.

Manure
Yield: 1.48 tons per acre

Manure, limestone, phosphorus
Yield: 2.90 tons per acre

FIG. 2.—CLOVER ON THE DAVENPORT PLOTS IN 1913

By comparing Plots 2 and 3 with Plots 4 and 5, it is found that limestone has had a beneficial effect on all crops. What the financial profit amounts to depends obviously upon the market value of the crops and the cost of the limestone.

Comparing Plots 4 and 5 with Plots 6 and 7, respectively, there is found in all cases an increase in crop yield as a result of adding phosphorus. The effect on wheat is especially pronounced. Where limestone and phosphorus are applied in addition to the crop residues, an increase of 17 bushels of wheat, over the yield of the untreated land, has been obtained as a ten-year average.

The effect of adding potassium to the treatment is of much interest. Plots 8 and 9 are the same as Plots 6 and 7, respectively, except that potassium has been applied to the former. On the whole, no significant benefit is shown from the addition of potassium.

No benefit appears as the result of the extra-heavy applications of manure and phosphorus on Plot 10. In fact the corn yields are noticeably less here than on the plots receiving the normal applications of these materials.

The University South Farm

On the University South Farm, at Urbana, several series of plots devoted primarily to variety testing and other crop-production experiments are so laid out as to show the effects of certain soil treatments that have been applied.

Several different systems of crop rotation are employed and the crops are so handled as to exemplify the two general systems of farming, grain and livestock.

The summarized results presented in Table 4 represent three different systems of cropping. The first, designated as the Southwest rotation, is to be regarded as a good rotation for general practice, on this type of soil, under Illinois conditions. This is a four-field rotation of wheat, corn, oats, and clover. The second, or North-Central rotation, consisting of corn, corn, oats, and clover, represents a system very commonly practiced; and the third or South-Central rotation, consisting of corn, corn, corn, and soybeans, must be considered as a poor rotation from the standpoint of maintaining the productiveness of the land.

TABLE 4.—URBANA FIELD, SOUTH FARM: BROWN SILT LOAM, PRAIRIE; EARLY WISCONSIN GLACIATION

Average Annual Yields—Bushels or (tons) per acre

Southwest Rotation: Series 100, 200, 400[1]: Wheat, Corn, Oats, Clover[2]

Soil treatment applied[6]	Corn 9 crops	Oats[3] 9 crops	Wheat[3] 8 crops	Clover[4] 3 crops	Soybeans 7 crops
RP	62.3	51.9	41.0	1.05	17.3[5]
R	51.9	46.5	26.9	1.38	16.2[5]
M	59.7	50.2	29.1	(2.28)	(1.25)
MP	64.3	55.4	43.1	(2.86)	(1.51)
RLP	60.5	57.2	41.8	.64	16.4[5]
R	49.7	49.6	25.8	.83	14.7[5]
M	55.5	54.1	27.8	(1.71)	(1.28)
MLP	64.1	59.6	43.9	(1.77)	(1.58)

North-Central Rotation: Series 500, 600, 700[1]: Corn, Corn, Oats, Clover[2]

Soil treatment applied[6]	Corn 1st year 9 crops	Corn 2d year 9 crops	Oats 9 crops	Clover 5 crops	Soybeans 4 crops
RP	56.7	51.1	56.1	.54	16.9
R	51.7	45.2	52.0	.50	16.0
M	54.9	46.7	52.1	(2.29)	(1.60)
MP	56.5	53.4	56.9	(2.73)	(1.74)

South-Central Rotation: Series 500, 600, 700[1]: Corn, Corn, Corn, Soybeans

Soil treatment applied[6]	Corn 1st year 9 crops	Corn 2d year 9 crops	Corn 3d year 9 crops		Soybeans 9 crops
RP	51.9	44.0	41.3		20.0
R	45.5	39.9	35.2		19.2
M	50.1	42.1	33.5		(1.59)
MP	54.5	46.7	42.0		(1.66)

[1]Results from Series 300 and 800 are omitted on account of variation in soil type.
[2]Soybeans when clover fails.
[3]Only seven crops with limestone.
[4]Only one crop with limestone.
[5]Average of five crops.
[6]All phosphorus plots received ½ ton per acre of limestone in 1903.

TABLE 5.—COMPARING PRODUCTION OF CORN IN THREE DIFFERENT ROTATION SYSTEMS
ACRE YIELDS FROM PLOTS ON THE UNIVERSITY SOUTH FARM
Twelve-Year Average (1908-1919)—Bushels per acre

Rotation	Wheat-corn-oats-legume[1]	Corn-corn-oats-legume[2]		Corn-corn-corn-legume[3]		
Treatment	Corn	1st Corn	2d Corn	1st Corn	2d Corn	3d Corn
Organic manures............	55.8	53.3	46.0	47.8	41.0	34.3
Organic manures, phosphorus.	63.2	56.6	52.3	53.2	45.3	41.6

[1]Clover 3 crops, and soybeans 7 crops.
[2]Clover 5 crops, and soybeans 5 crops.
[3]Soybeans 9 crops.

On the whole, the "residues" have not returned yields quite so high as those produced by the manure treatment; but, as remarked above in the discussion of the Davenport plots, the residues system has probably been at a disadvantage thru frequent clover failures. On the North-Central rotation, where conditions seem to have been more favorable for clover, there is very little difference between the effect of manure and of residues.

Residues plowed under
Yield: 35.2 bushels per acre

Residues and rock phosphate
Yield: 50.1 bushels per acre

FIG. 3.—WHEAT ON THE UNIVERSITY SOUTH FARM IN 1911

In the rotation system in which limestone is being applied, no benefit of consequence to any of the crops except oats appears from the use of this material. The test, however, has hardly been of sufficient duration to warrant final conclusions; and furthermore, the comparison may be somewhat impaired by a possible residual effect of the small application of limestone made in 1903 to all the phosphorus plots.

The results obtained from the use of phosphorus are important because this element has been applied to these plots solely in the form of raw rock phosphate. The figures in almost every case show an increase in yield where the phosphorus has been applied, and in most cases this increase is very pronounced. The wheat is especially responsive to phosphorus.

The records furnish some interesting comparisons of corn yields produced under different systems of cropping. Table 5 gives a general summary of the corn yields only, in which the results from the residues and manure treatments are averaged together as "organic manures." The highest annual acre-yields are found where corn occurs but once in a rotation. Where corn is grown twice in succession, the annual acre-yields are less; and where corn occurs three times, there is a further reduction. Also, the first crop of corn within a rotation produces more than the second, and the second crop yields more than the third. These are useful facts for consideration in connection with problems of general farm management.

Experiment Fields in Bureau County

It happens that there are two experiment fields located within the borders of Bureau county, one near La Moille and the other at Spring Valley. Both of these fields are on the brown silt loam of the early Wisconsin glaciation but the Spring Valley field represents a phase of the type that was formerly timbered.

The La Moille Field

The first experimental crops were grown on the La Moille field in 1910. Two cropping systems are being carried on. The main system is the standard rotation of wheat, corn, oats, and clover. In addition to this, a minor rotation of potatoes and alfalfa has been conducted on other plots in which potatoes occupied the land for two years and were followed by six years of alfalfa. This latter rotation was changed in 1921 to one consisting of corn, corn, wheat, and alsike clover. A diagram of the La Moille field, showing the arrangement of the plots, is presented as Fig. 4.

Table 6 shows the treatment of plots and the summarized results for the years since full treatment has been under way.

In considering these results it should be taken into account that this field is not altogether uniform. As a matter of fact some of the untreated, or check, plots are among those most favorably located, and this places upon many of the treated plots a handicap which will require time to overcome. The annual records, which are not given here in the summarized results, reveal the fact that progressive improvement is taking effect as a result of proper treatment. The increases due to proper treatment are much more marked in the later than in the earlier years, thus indicating that the treated plots are becoming better or the check plots are becoming poorer, or, what is more probable, that both of these effects are taking place.

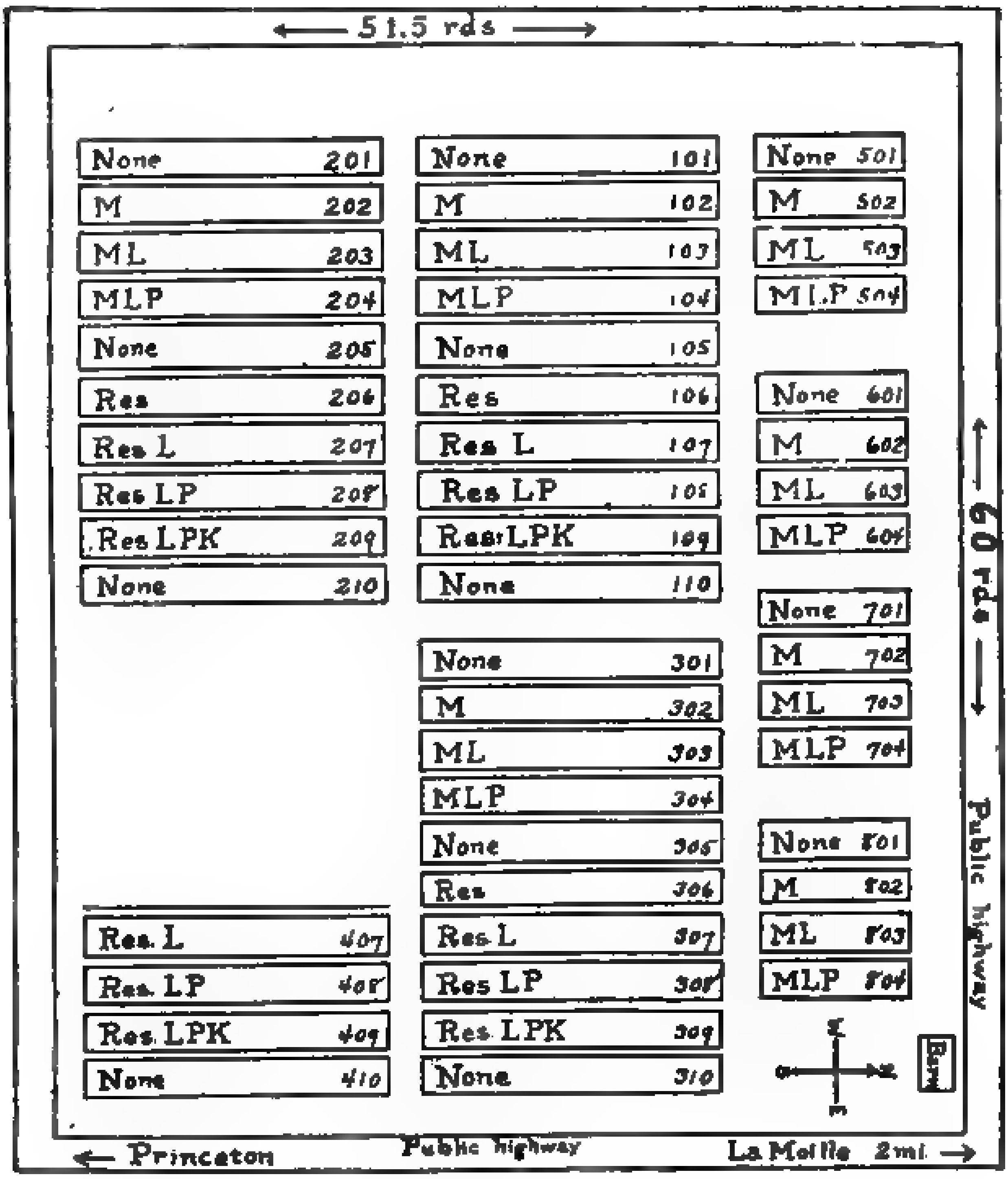


FIG. 4.—DIAGRAM SHOWING ARRANGEMENT OF PLOTS ON THE LA MOILLE EXPERIMENT FIELD.

TABLE 6.—LA MOILLE FIELD: BROWN SILT LOAM, PRAIRIE; LATE WISCONSIN GLACIATION

Average Annual Yields—Bushels or (tons) per acre

		Main Rotation							Minor Rotation	
					Legumes					
Serial plot No.	Soil treatment applied	Wheat	Corn	Oats	Clover 6 crops		Soybeans 1 crop		Alfalfa	Potatoes
		6 crops	8 crops	8 crops	Hay	Seed	Hay	Seed	10 crops	8 crops
1	0.......	28.0	44 2	67.1	(2.46)	....	(2 20)	....	(2 34)	103 2
2	M.....	37.9	54.4	73.7	(2 86)	....	(2 20)	....	(2.80)	135 8
3	ML.....	39.4	52 7	72.6	(2.90)	....	(2.18)	....	(2.83)	130.0
[illegible]	MLP...	39.2	53 2	70 8	(2 90)	....	(2 20)	....	(2 69)	121 8
5	0.......	36 2	39.9	59 3	(96)	1 06	....	16 2	... .	.
6	R......	38 2	48.4	72.0	(.95)	67	....	16 8	....	....
7	RL....	39 8	49.8	70.9	(1.05)	.73	... .	16 6	....	..
8	RLP....	41.0	51.0	73 4	(1 04)	.82	....	14 4	....	.
9	RLPK	40.9	49 1	71 1	(1 03)	89	....	14 7	... .	
10	0.......	31.1	37 4	61.8	(2.73)	....	(1 96)	....	. .	....

The data thus far obtained indicate that the addition of organic matter to the soil, whether in the form of animal manures or plant manures, has produced beneficial effects. Limestone on the whole seems to have produced no marked effect on this field. Phosphorus has as yet returned no profit when applied with manure and limestone, but when applied in the residue system gains in yield in all of the grain crops are shown. It is probable that as time goes on, and the nitrogen supply becomes built up thru the incorporation of organic matter, phosphorus will become a limiting element and greater profit will result from its use. The application of potassium has produced no significant results.

The Spring Valley Field

The Spring Valley field is located on the grounds of the Township High School. This land was formerly timbered. The surface is very rolling. In fact, the contour is so uneven as to render the plot comparisons very difficult in some cases.

The field is laid out in two rotations, a major and a minor. The major crop rotation consists of wheat, corn, oats, and clover and occupies four series of plots with 12 plots in each series. The minor rotation, on the shorter series, consists of corn, corn (for silage), and oats (with sweet clover seeding) while alfalfa occupies the fourth series. Figure 5 shows the arrangement of these plots.

Inasmuch as this field has been so recently established and so few results have been obtained since full treatment has been in effect, no attempt is made at this time to summarize the results. However, for the benefit of those who are interested in watching developments on these plots, the tabulated yields of all crops harvested up to 1921 are presented in Table 7.

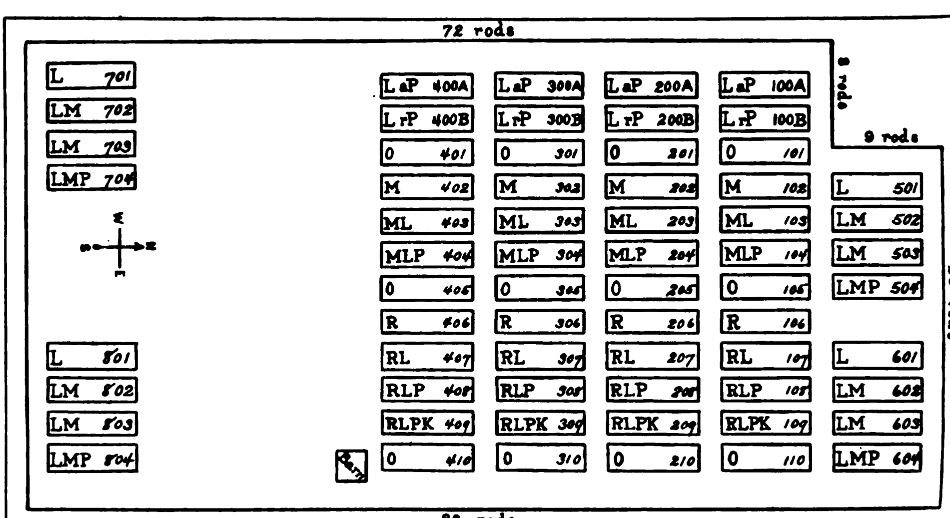


FIG. 5.—DIAGRAM SHOWING ARRANGEMENT OF PLOTS ON THE SPRING VALLEY EXPERIMENT FIELD

TABLE 7.—SPRING VALLEY FIELD: BROWN SILT LOAM, FORMERLY TIMBERED; EARLY WISCONSIN GLACIATION

Average Annual Yields—Bushels or (tons) per acre

Plot No.	Soil treatment applied	1915[1]	1916	1917	1918	1919	1920
		Corn	Oats[2]	Clover[2]	Wheat[2]	Corn	Oats
100A[3]	L aP						
100B[3]	L rP						
101	0	34.8	35.9	(2.26)	53.2	41.6	55.3
102	M	27.8	32.5	(1.83)	46.0	42.4	51.6
103	ML	26.4	29.7	(2.36)	51.0	47.6	50.6
104	MLP	34.4	35.9	(2.40)	50.3	55.6	60.0
105	0	35.0	26.9	.03	55.3	43.6	50.6
106	R	30.4	31.2	.05	55.0	54.4	40.0
107	RL	31.2	34.4	.03	56.3	57.2	46.9
108	RLP	30.2	38.1	.05	57.2	56.8	52.2
109	RLPK	33.0	36.9	.03	49.7	66.0	58.8
110	0	35.0	35.9	(1.34)	45.2	30.8	48.1
		Wheat	Corn	Oats	Clover	Wheat	Corn
200A[3]	L aP						
200B[3]	L rP						
201	0	19.0	25.8	56.2	(3.84)	33.5	38.2
202	M	8.2	13.8	44.1	(4.26)	32.5	54.0
203	ML	6.3	10.4	39.1	(4.20)	32.7	53.8
204	MLP	15.5	17.8	49.7	(4.57)	34.3	55.0
205	0	15.8	14.6	40.9	(3.11) | .25	33.5	39.0
206	R	15.5	19.8	39.7	(3.37) | .42	30.8	47.4
207	RL	21.2	30.0	47.8	(3.55) | .67	33.3	50.6
208	RLP	20.8	26.2	55.6	(3.77) | 1.17	33.8	53.0
209	RLPK	18.8	25.0	42.2	(3.38) | .50	31.3	53.4
210	0	13.5	20.2	42.5	(4.56)	31.5	35.6
		Soybeans	Wheat[2]	Corn	Oats	Clover	Wheat
300A[3]	L aP						
300B[3]	L rP						
301	0	(1.45)	26.0	23.6	46.6	(2.87)	25.3
302	M	(1.36)	17.3	32.4	45.9	(2.94)	23.8
303	ML	(1.40)	16.3	29.6	37.5	(2.72)	26.7
304	MLP	(1.54)	21.2	44.0	50.0	(3.42)	29.3
305	0	16.5	20.7	23.8	39.4	(1.58)	21.7
306	R	17.2	17.2	46.2	54.7	(2.04)	24.3
307	RL	17.3	23.8	48.0	55.0	(2.00)	33.8
308	RLP	17.5	19.2	45.6	62.2	(1.81)	33.5
309	RLPK	17.0	14.3	50.4	50.0	(1.95)	26.7
310	0	(1.36)	16.7	20.0	35.9	(2.70)	21.2
		Oats	Clover[2]	Wheat[2]	Corn	Oats	Clover
400A[3]	L aP						
400B[3]	L rP						
401	0	41.2	(2.31)	36.5	54.4	36.9	(2.23)
402	M	38.4	(2.00)	33.0	58.0	38.8	(2.48)
403	ML	23.1	(1.92)	32.8	57.2	39.1	(2.22)
404	MLP	34.7	(2.33)	38.2	63.6	40.9	(2.50)
405	0	33.8	.10	35.0	50.4	36.6	(1.46) | 1.40
406	R	28.8	.17	37.3	57.2	34.7	(1.58) | 1.87
407	RL	38.1	.12	39.3	67.6	54.1	(1.58) | 1.95
408	RLP	32.5	.15	41.8	64.0	45.9	(1.68) | 2.02
409	RLPK	38.8	.15	39.0	76.8	48.8	(1.47) | 1.87
410	0	31.9	(2.33)	35.0	59.2	45.6	(2.39)

[1]Lime only. [2]No manure.

[3]In 1917 Plots A and B were added to each of the four series from 100 to 400 for the purpose of making a comparative phosphorus test. The treatment for this test was not begun until 1921. This treatment is as follows: on Plot A of each series, acid phosphate at the rate of 200 pounds per acre per year; on Plot B, finely ground rock phosphate at the rate of 400 pounds per acre per year; on both A and B, limestone at the rate of 500 pounds per acre per year, which is one-half of the usual rate.

An analysis of these yields shows that increasing gains for the better treatments are already being obtained, thus indicating that as time goes on the differences between the treated plots and the check plots will become more and more pronounced.

While it is far too early to draw final conclusions it is of interest to note a few points which the experiments seem to indicate. The possibility of building up this land thru the use of legumes and crop residues in connection with the application of limestone is already becoming apparent. While it is doubtful whether the gains produced by phosphorus are sufficient as yet to represent actual financial profit, it is altogether probable that the results will become more favorable for phosphorus as time goes on. As to the effect of potassium on this soil, it is clear that in the system of farming practiced, this material has been applied at a financial loss.

BLACK CLAY LOAM

The Hartsburg experiment field, representing black clay loam of the middle Illinoisan glaciation, is located in Logan county just east of Hartsburg. The work was begun here in 1913. There are five series of ten plots each. A crop rotation of wheat, corn, oats, and clover, with alfalfa on a fifth field, is practiced. The soil treatments are as indicated in Table 8. The table also summarizes the yields, by crops, for the period during which the plots have been under full treatment.

Under the conditions of these experiments, residues alone have proved to be more effective than manure alone in the production of wheat, corn, and oats.

Limestone used with manure has given such greatly increased yields as to leave no doubt about the profitableness of its use. When applied with residues, however, there appears to be on the whole little advantage from the use of limestone.

TABLE 8.—HARTSBURG FIELD: BLACK CLAY LOAM, PRAIRIE; MIDDLE ILLINOISAN GLACIATION

Average Annual Yields—Bushels or (tons) per acre

Serial plot No.	Soil treatment applied	Wheat 5 crops	Corn 8 crops	Oats 7 crops	Clover 4 crops	Soybeans 2 crops	Alfalfa 8 crops[1]
1	0	22.6	43.4	45.4	(1.98)	(1.29)	(3.30)
2	M	27.4	48.3	50.2	(2.41)	(1.64)	(3.61)
3	ML	34.2	56.9	57.9	(2.51)	(1.82)	(3.83)
4	MLP	38.2	.56.0	57.3	(2.62)	(1.92)	(4.04)
5	0	33.3	46.8	43.8	.74[2]	25.8	(3.19)
6	R	34.0	58.2	55.6	1.22[2]	26.8	(3.60)
7	RL	32.0	63.7	54.9	1.32[2]	28.4	(3.28)
8	RLP	36.4	61.1	59.0	1.41[2]	26.1	(3.83)
9	RLPK	35.2	59.5	57.2	1.42[2]	26.4	(4.01)
10	0	31.7	46.7	46.9	(2.14)	(1.69)	(3.02)

[1]No residues except on last two crops.
[2]In addition to the clover seed, hay was harvested on Plots 5, 6, 7, 8, and 9 amounting to .56, 1.01, 1.11, 1.20, and 1.03 tons, respectively.

Phosphorus has given good returns on the wheat crop, but with the other crops its recommendation would be doubtful. In this connection attention should be called to the fact that chemical analysis of this black clay loam type generally shows a relatively high phosphorus content. The experience on this field seems to bear out what the analyses show.

The addition of potassium has produced a depressing effect on the yields of all grain crops, and with the alfalfa the small gain could scarcely be considered significant.

YELLOW-GRAY SILT LOAM

Yellow-gray silt loam exhibits an important variation with respect to limestone content. In some areas, altho limestone may be altogether absent in the surface stratum it is found in abundance at a short distance beneath the surface. Accordingly, variations in response to soil treatment are exhibited by different experiment fields located on this type. In view of this discrepancy it is thought well to introduce here the records of two fields, that are representative of the type but which show a marked diversity in results, one in northern Illinois and one in the southern part of the state.

The Antioch field is located on the late Wisconsin glaciation, in Lake county, close to the Wisconsin border. The field was started in 1902, with but a single series of ten plots, under a rotation of corn, corn, oats, and wheat; but beginning with 1911 the rotation has been wheat, corn, oats, and clover. It was started in order to learn as quickly as possible what effect would be produced by the addition to this type of soil of nitrogen, phosphorus, and potassium, used singly and in combination. These elements were all applied in commercial form until 1911, after which the use of commercial nitrogen was discontinued and crop residues were substituted in its place. Nitrogen was supplied in the earlier years in 800 pounds per acre of dried blood. Phosphorus is applied in 200 pounds of steamed bone meal, and potassium in 100 pounds of potassium sulfate. At the beginning, 470 pounds of slaked lime was applied; but since 1912 limestone has been applied at the rate of 1,000 pounds per acre per year.

TABLE 9.—ANTIOCH FIELD: YELLOW-GRAY SILT LOAM, TIMBER SOIL; LATE WISCONSIN GLACIATION

Average Annual Yields—Bushels or (tons) per acre

Serial plot No.	Soil treatment applied	Corn 8 crops	Oats 5 crops	Wheat 4 crops	Clover seed 2 crops
1	0	23.9	32.3	15.8	.50
2	L	21.3	26.8	13.2	.30
3	LR	21.3	29.9	20.6	.33
4	LP	30.7	43.6	36.7	1.08
5	LK	23.7	27.8	19.2	.57
6	LRP	33.8	43.3	33.3	.57
7	LRK	24.3	26.9	20.8	.59
8	LPK	25.1	38.2	30.9	1.26
9	LRPK	38.3	42.6	28.0	.33
10	RPK	38.4	44.7	30.2	.67

Manure, limestone, phosphorus
Yield: 61 bushels per acre

Nothing applied
Yield: 15 bushels per acre

FIG. 6.—CORN ON RALEIGH FIELD IN 1920

Table 9 presents, in summarized form, the results from the Antioch field. Because of an abnormality in Plot 1, the results from this plot are not considered. The data show that phosphorus is the one element standing out prominently as producing consistently beneficial results. Potassium applied in addition to phosphorus has, on the whole, not produced profitable results. Also, the results are unfavorable for the application of limestone. Limestone, however, is abundant in the subsoil of this type in the region of this field.

The Raleigh experiment field is located on the lower Illinoisan glaciation, in southern Illinois, in Saline county. This field is laid out into four series of ten plots each, under a rotation of wheat, corn, oats, and clover. The treatments, along with the summarized results, are given in Table 10.

The outstanding feature of these results is the effect of limestone. Altho manure alone produces a substantial increase, especially in the corn crop, when limestone is added a remarkable increase is found in all crops. A most important fact is that the organic matter can be effectively built up thru the use of crop residues, with the application of limestone, so that the crop yields are practically as high under this "grain system" of farming as where manure is used.

Phosphorus thus far has given only moderate returns in increased crop yields, but with an increasing quantity of organic matter and nitrogen it is probable that the phosphorus applications will show up more favorably on subsequent crops. As to the use of potassium, it is to be noted that aside from an increase of 5.4 bushels of corn in the residues system, the beneficial effect has not been sufficient to justify the use of this material.

TABLE 10.—RALEIGH FIELD: YELLOW-GRAY SILT LOAM, TIMBER SOIL; LOWER ILLINOISAN GLACIATION

Average Annual Yields—Bushels or (tons) per acre

Serial plot No.	Soil treatment applied	Corn 10 crops	Oats 10 crops	Wheat 6 crops	Clover 4 crops	Soybeans 4 crops
1	0	17.3	10.4	5.8	(.26)	(.65)
2	M	29.7	13.0	7.7	(.31)	(.81)
3	ML	40.9	20.0	21.0	(1.08)	(1.08)
4	MLP	41.2	20.3	21.5	(1.32)	(1.24)
5	0	17.3	10.3	7.0	(.00) .01[2]	2.3
6	R	20.1	12.8	8.4	(.00) .01[2]	3.0
7	RL	34.9	21.5	18.8	(1.60)[1] .10[2]	5.8
8	RLP	36.5	22.7	21.2	(1.61)[1] .09[2]	6.8
9	RLPK	41.9	23.6	22.4	(1.79)[1] .12[2]	6.0
10	0	19.6	11.6	6.5	(1.06)	(.57)

[1]One crop only (1920).
[2]Average of two crops.

In accounting for the discrepancy in the response to limestone on these two fields, the fact is to be considered that the Antioch field is located on the late Wisconsin glaciation, where the subsoil contains large quantities of limestone; while the Raleigh field represents the lower Illinoisan glaciation, the soil of which is very acid to a great depth.

In view of these variations, a general recommendation for a complete treatment for soil of this type, that will apply to all localities, cannot be given out until more information is acquired.

Fortunately, however, each farmer can determine for himself the need of limestone for his land by applying the simple tests for the presence of carbonates and soil acidity, as explained under the discussion of limestone on page 43 of the Appendix.

Phosphorus, which has paid well on the Antioch field, and has given doubtful returns thus far at Raleigh, has varied considerably in its effect when used on other fields located on this same type of soil. In this situation, therefore, the present suggestion would be that each farmer might well try out phosphorus on his own land, on a limited scale, and be guided by the outcome of his experience. The low phosphorus content of the surface stratum of this soil is an indication that in a system of permanent agriculture the time is not far off when phosphorus will become a limiting element to crop production, and the wise farmer will watch carefully the indications and be ready to make timely provision for this need.

YELLOW SILT LOAM

A soil fertility experiment field on yellow silt loam is located at Elizabethtown, in the southern end of the state, but this field has not been in operation long enough to furnish results that can be used.

FIG. 7.—WHEAT IN POT-CULTURE EXPERIMENT WITH YELLOW SILT LOAM OF WORN HILL LAND
The need of nitrogen (N) on this type of soil is clearly demonstrated.

TABLE 11.—CROP YIELDS IN POT-CULTURE EXPERIMENT WITH YELLOW SILT LOAM OF WORN HILL LAND

Grams per pot

Pot No.	Soil treatment applied	Wheat	Oats
1	None	3	5
2	Limestone	4	4
3	Limestone, nitrogen	26	45
4	Limestone, phosphorus	3	6
5	Limestone, potassium	3	5
6	Limestone, nitrogen, phosphorus	34	38
7	Limestone, nitrogen, potassium	33	46
8	Limestone, phosphorus, potassium	2	5
9	Limestone, nitrogen, phosphorus, potassium	34	38
10	None	3	5
Average yield with nitrogen		32	42
Average yield without nitrogen		3	5
Average gain for nitrogen		29	37

However, some experiments in pot culture have been conducted with soil of this type, the results of which furnish useful data in indicating the proper management of this kind of soil.

In one experiment a large quantity of typical worn hill soil was collected from two different places. Each lot of soil was thoroly mixed and put into ten four-gallon jars. Wheat was planted in one series and oats in the other. Ground limestone was added to all the jars except the first and last in each set, those two being retained as control, or check pots. The elements nitrogen, phosphorus, and potassium were added singly and in combination, as shown in Table 11.

As an average, the yield produced where nitrogen was applied, was about eight times as large as that secured without the addition of nitrogen.

But there is no need whatever to purchase nitrogen, for the air contains an inexhaustible supply of it which, under suitable conditions, the farmer can draw upon, not only without cost, but with profit in the getting. Clover, alfalfa,

FIG. 8.—WHEAT IN POT-CULTURE EXPERIMENT WITH YELLOW SILT LOAM OF WORN HILL LAND
In the pots at the right, nitrogen is applied in commercial form. In the pots at the left, nitrogen is secured from the air thru the growing of legumes.

TABLE 12.—CROP YIELDS IN POT-CULTURE EXPERIMENT WITH YELLOW SILT LOAM OF WORN HILL LAND AND NITROGEN-FIXING GREEN MANURE CROPS

Grams per pot

Pot No.	Soil treatment applied	1903 Wheat	1904 Wheat	1905 Wheat	1906 Wheat	1907 Oats
1	None	5	4	4	[illegible]	6
2	Limestone, legume	10	17	[illegible]	19	37
11	Limestone, legume, phosphorus	14	19	20	18	27
12	Limestone, legume, phosphorus, potassium	[illegible]	20	21	19	30
3	Limestone, nitrogen	17	14	15	[illegible]	28
6	Limestone, nitrogen, phosphorus	26	20	18	18	30
9	Limestone, nitrogen, phosphorus, potassium	31	34	21	20	26
8	Limestone, phosphorus, potassium	3	[illegible]	5	3	7

sweet clover, cowpeas, and soybeans are worth raising not only because of their value as crops but because of their power, when properly inoculated with nitrogen-fixing bacteria, to secure nitrogen from the atmosphere.

In order to secure further information concerning the best practice in building up the nitrogen content, another experiment with pot cultures was conducted for several years with the same kind of worn hill soil as that used for wheat in the former experiment. The results are reported in Table 12.

To three pots (Nos. 3, 6, and 9) nitrogen was applied, in commercial form, at an expense amounting to more than the total value of the crops produced. In three other pots (Nos. 2, 11, and 12) a crop of cowpeas was grown during the late summer and fall and turned under before the wheat or oats were planted. Pots 1 and 8 served for important comparisons. After the second cover crop of cowpeas had been turned under, the yield from Pot 2 exceeded that from Pot 3; and in the subsequent years the green manure from legumes produced, as an average, somewhat better results than the commercial nitrogen. This experiment confirms the previous one in showing the very great need for nitrogen for the improvement of this type of soil—and it also shows that nitrogen need not be purchased but that it can be obtained from the air by growing legume

crops and plowing them under as green manure. Of course the soil can be very markedly improved by feeding the legume crops to live stock and returning the resulting farm manure to the land, if legumes are grown frequently enough and if the farm manure produced is sufficiently abundant and is saved and applied with care.

It may not be advisable in all cases to enrich this type of soil in phosphorus, for with erosion, which is sure to occur to some extent, the phosphorus supply will be renewed from the subsoil.

Probably the best legumes for this type of soil are sweet clover and alfalfa. On soil deficient in organic matter, sweet clover grows better than almost any other legume, and the fact that it is a very deep-rooting plant makes it of value in increasing the organic matter and in preventing washing. Worthless slopes, where the land has been ruined by washing, may be made profitable as pasture by growing sweet clover. The blue grass of pastures may well be supplemented by sweet clover and alfalfa, and a larger growth obtained, because the legumes provide the necessary nitrogen for the blue grass.

To get alfalfa started well requires the liberal use of limestone, thoro inoculation with nitrogen-fixing bacteria, and a moderate application of farm manure. If manure is not available, it is well to apply about 500 pounds per acre of acid phosphate or steamed bone meal, mix it with the soil, by disking if possible, and then plow it under. The limestone (about 5 tons) should be applied after plowing and should be mixed with the surface soil in the preparation of the seed bed. The special purpose of this treatment is to give the alfalfa a quick start in order that it may grow rapidly and thus protect the soil from washing.

DUNE SAND

In 1913 the University came into possession of a tract of dune sand on terrace, in Henderson county, near the Mississippi river, upon which an experiment field was laid out to determine the needs of these sand soils. This field is divided into six series of plots. Corn, soybeans, wheat, sweet clover, and rye, with a catch crop of sweet clover seeded in the rye on the residues plots, are grown in rotation on five series, while the sixth series is devoted to alfalfa. When sweet clover seeded in the wheat fails, cowpeas are substituted.

No catch of alfalfa or of sweet clover was obtained till the alfalfa drill was used in seeding. This covers the seed about one-half inch deep.

Table 13 indicates the kinds of treatment applied, the amounts of the materials used being in accord with the standard practice, as explained on page 52.

The data make apparent the remarkably beneficial action of limestone on this sand soil. Where limestone has been used in conjunction with crop residues, the yield of corn has been doubled. The limestone has also produced a fair crop of rye and excellent crops of sweet clover and alfalfa.

This land appears to be quite indifferent to phosphorus treatment. The analysis shows, however, that the stock of phosphorus in this type of soil is not large, and it may develop as time goes on and the supply diminishes along with the production of good-sized crops, that the application of this element will become profitable.

Manure
Yield: Nothing

Manure and limestone
Yield: 4.43 tons per acre

FIG. 9.—ALFALFA ON OQUAWKA FIELD IN 1918

Altho the results show an increase of 3.4 bushels of corn from the use of potassium salts, with ordinary prices this would not be a profitable treatment. The .64 bushel gain in sweet-clover seed is the average of two crops only, and this is insufficient data upon which to base conclusions. The other crops all show negative results from the potassium application.

Experience thus far shows rye to be better adapted to this land than wheat, and both alfalfa and sweet clover thrive better than soybeans. With these two

TABLE 13.—OQUAWKA FIELD: DUNE SAND, TERRACE
Average Annual Yields—Bushels or (tons) per acre

Serial plot No.	Soil treatment applied	Corn 6 crops	Soy-beans[1] 5 crops	Wheat 6 crops	Sweet clover 4 crops		Rye 4 crops	Alfalfa 3 crops
1	0	14.3	(.89)	6.4	0		12.1	(.11)
2	M	18.9	(1.01)	8.1	0		13.3	(.13)
3	ML	23.4	(1.27)	9.7	(1.20)		20.1	(1.88)
4	MLP	22.2	(1.20)	10.1	(1.26)		19.5	(2 03)
					2 crops	2 crops		
5	0	14.4	3.5	7.4	(0)	0	13.7	(.14)
6	R	16.2	3.5	8.1	(0)	0	14.1	(.12)
7	RL	29.3	6.6	9.1	(1.47)	2.53	23.2	(2.05)
8	RLP	29.3	6.4	10.4	(1.39)	2.20	24.2	(1.90)
9	RLPK	32 7	6.0	9.4	(1 53)	2 84	23 7	(1.86)
10	0	11 4	(.60)	6.4	(0)		10 6	(.06)

[1] In 1918 sweet clover was killed by being cut for hay. Soybeans were seeded on these plots and the following yields obtained: .86, 1.10, 1.93, and 2.00 tons of hay per acre on Plots 1 to 4; 11.1, 9.9, 14.6, 15.8, and 16.6 bushels of seed per acre on Plots 5 to 9; and .62 ton of hay per acre on Plot 10.

legume crops thriving so well under this simple treatment, we have promise of tremendous possibilities for the profitable culture of this land, which hitherto has been considered as practically worthless.

Deep Peat

As representing the deep peat type of soil, the results are introduced from an experiment field conducted at Manito in Mason county during the years 1902 to 1905 inclusive.

There were ten plots receiving the treatments indicated in Table 14.

The results of the four years' tests, as given in Table 14, are in complete harmony with the information furnished by the chemical composition of peat soil. Where potassium was applied, the yield was from three to four times as large as where nothing was applied. Where approximately equal money values of kainit and potassium chlorid were applied, slightly greater yields were obtained with the potassium chlorid, which, however, supplied about one-third more potassium than the kainit. On the other hand, either material furnished more potassium than was required by the crops produced.

The use of 700 pounds of sodium chlorid (common salt) produced no appreciable increase over the best untreated plots, indicating that where potassium is itself actually deficient, salts of other elements cannot take its place.

Applications of 2 tons per acre of ground limestone produced no increase in the corn crops, either when applied alone or in combination with kainit, either the first year or the second.

Reducing the application of kainit from 600 to 300 pounds for each two-year period reduced the yield of corn from 164.5 to 125.9 bushels. The two applications of 300 pounds of kainit (Plot 9) furnished 60 pounds of potassium for the four years, an amount sufficient for 84 bushels of corn (grain and stalks). Attention is called to the fact that this is practically the difference between the yield of Plot 9 (125.9 bushels) and the yield obtained from Plot 2 (42.9 bushels), the poorest untreated plot.

TABLE 14.—MANITO FIELD: DEEP PEAT
Corn Yields—Bushels

Plot No.	Soil treatment for 1902	Corn 1902	Corn 1903	Soil treatment for 1904	Corn 1904	Corn 1905	Four crops
1	None	10.9	8.1	None	17.0	12.0	48.0
2	None	10.4	10.4	Limestone, 4000 lbs.	12.0	10.1	42.9
3	Kainit, 600 lbs.	30.4	32.4	Limestone, 4000 lbs.; Kainit, 1200 lbs.	49.6	47.3	159.7
4	Kainit, 600 lbs.; Acidulat'd bone, 350 lb.	30.3	33.3	Kainit, 1200 lbs.; Steamed bone, 395 lbs.	53.5	47.6	164.7
5	Potassium chlorid, 200 lbs.	31.2	33.9	Potassium chlorid, 400 lbs.	48.5	52.7	166.3
6	Sodium chlorid, 700 lbs.	11.1	13.1	None	24.0	22.1	70.3
7	Sodium chlorid, 700 lbs.	13.3	14.5	Kainit, 1200 lbs.	44.5	47.3	......
8	Kainit, 600 lbs.	36.8	37.7	Kainit, 600 lbs.	44.0	46.0	164.5
9	Kainit, 300 lbs.	26.4	25.1	Kainit, 300 lbs.	41.5	32.9	125.9
10	None	14.9[1]	14.9	None	26.0	13.6	69.4

[1]Estimated from 1903; no yield was taken in 1902 because of a misunderstanding.

Manure, limestone, phosphorus
Yield: 61 bushels per acre

Nothing applied
Yield: 15 bushels per acre

FIG. 6.—CORN ON RALEIGH FIELD IN 1920

Table 9 presents, in summarized form, the results from the Antioch field. Because of an abnormality in Plot 1, the results from this plot are not considered. The data show that phosphorus is the one element standing out prominently as producing consistently beneficial results. Potassium applied in addition to phosphorus has, on the whole, not produced profitable results. Also, the results are unfavorable for the application of limestone. Limestone, however, is abundant in the subsoil of this type in the region of this field.

The Raleigh experiment field is located on the lower Illinoisan glaciation, in southern Illinois, in Saline county. This field is laid out into four series of ten plots each, under a rotation of wheat, corn, oats, and clover. The treatments, along with the summarized results, are given in Table 10.

The outstanding feature of these results is the effect of limestone. Altho manure alone produces a substantial increase, especially in the corn crop, when limestone is added a remarkable increase is found in all crops. A most important fact is that the organic matter can be effectively built up thru the use of crop residues, with the application of limestone, so that the crop yields are practically as high under this "grain system" of farming as where manure is used.

Phosphorus thus far has given only moderate returns in increased crop yields, but with an increasing quantity of organic matter and nitrogen it is probable that the phosphorus applications will show up more favorably on subsequent crops. As to the use of potassium, it is to be noted that aside from an increase of 5.4 bushels of corn in the residues system, the beneficial effect has not been sufficient to justify the use of this material.

TABLE 10.—RALEIGH FIELD: YELLOW-GRAY SILT LOAM, TIMBER SOIL; LOWER ILLINOISAN GLACIATION

Average Annual Yields—Bushels or (tons) per acre

Serial plot No.	Soil treatment applied	Corn 10 crops	Oats 10 crops	Wheat 6 crops	Clover 4 crops	Soybeans 4 crops
1	0	17.3	10.4	5.8	(.26)	(.65)
2	M	29.7	13.0	7.7	(.31)	(.81)
3	ML	40.9	20.0	21.0	(1.08)	(1.08)
4	MLP	41.2	20.3	21.5	(1.32)	(1.24)
5	0	17.3	10.3	7.0	(.00) .01[2]	2.3
6	R	20.1	12.8	8.4	(.00) .01[2]	3.0
7	RL	34.9	21.5	18.8	(1.60)[1] .10[2]	5.8
8	RLP	36.5	22.7	21.2	(1.61)[1] .09[2]	6.8
9	RLPK	41.9	23.6	22.4	(1.79)[1] .12[2]	6.0
10	0	19.6	11.6	6.5	(1.06)	(.57)

[1]One crop only (1920).
[2]Average of two crops.

In accounting for the discrepancy in the response to limestone on these two fields, the fact is to be considered that the Antioch field is located on the late Wisconsin glaciation, where the subsoil contains large quantities of limestone; while the Raleigh field represents the lower Illinoisan glaciation, the soil of which is very acid to a great depth.

In view of these variations, a general recommendation for a complete treatment for soil of this type, that will apply to all localities, cannot be given out until more information is acquired.

Fortunately, however, each farmer can determine for himself the need of limestone for his land by applying the simple tests for the presence of carbonates and soil acidity, as explained under the discussion of limestone on page 43 of the Appendix.

Phosphorus, which has paid well on the Antioch field, and has given doubtful returns thus far at Raleigh, has varied considerably in its effect when used on other fields located on this same type of soil. In this situation, therefore, the present suggestion would be that each farmer might well try out phosphorus on his own land, on a limited scale, and be guided by the outcome of his experience. The low phosphorus content of the surface stratum of this soil is an indication that in a system of permanent agriculture the time is not far off when phosphorus will become a limiting element to crop production, and the wise farmer will watch carefully the indications and be ready to make timely provision for this need.

YELLOW SILT LOAM

A soil fertility experiment field on yellow silt loam is located at Elizabethtown, in the southern end of the state, but this field has not been in operation long enough to furnish results that can be used.

IN RECOGNITION

The Soil Survey of Illinois was organized under the supervision of the late Dr. Cyril G. Hopkins. The work progressed for eighteen years under his guidance and the first eighteen soil reports bear his name as senior author. On October 6, 1919, Dr. Hopkins died in a foreign land in the service of the American Red Cross. It is the purpose to carry on to completion this great work of the Illinois Soil Survey in the spirit, and along the same general plan and lines of procedure, in which it was begun.

INTRODUCTORY NOTE

It is a matter of common observation that soils vary tremendously in their productive power, depending upon their physical condition, their chemical composition, and their biological activities. For any comprehensive plan of soil improvement looking toward the permanent maintenance of our agricultural lands, a definite knowledge of the various existing kinds or types of soil is a first essential. It is the purpose of a soil survey to classify the various kinds of soil of a given area in such a manner as to permit definite characterization for description and for mapping. With the information that such a survey affords, every farmer or land owner of the surveyed area has at hand the basis for a rational system of improvement of his land. At the same time the Experiment Station is furnished an inventory of the soils of the state, upon which intelligently to base plans for those fundamental investigations so necessary for solving the problems of practical soil improvement.

This county soil report is one of a series reporting the results of the soil survey which, when completed, will cover the state of Illinois. Each county report is intended to be as nearly complete in itself as it is practicable to make it, even at the expense of some repetition. There is presented in the form of an Appendix a general discussion of the important principles of soil fertility, in order to help the farmer and land owner to understand the significance of the data furnished by the soil survey and to make intelligent application of the same in the maintenance and improvement of the land. In many cases it will be of advantage to study the Appendix in advance of the soil report proper.

Data from experiment fields representing the more extensive types of soil, and furnishing valuable information regarding effective practices in soil management, are embodied in form of a Supplement. This Supplement should be referred to in connection with the descriptions of the respective soil types found in the body of the report.

CONTENTS OF SOIL REPORT No. 21

McHENRY COUNTY SOILS

APPENDIX

SUPPLEMENT

McHENRY COUNTY SOILS

By J. G. MOSIER, R. W. DICKENSON, H. W. STEWART, E. VAN ALSTINE AND H. J. SNIDER

PREPARED FOR PUBLICATION BY L. H. SMITH[1]

FORMATION

McHenry county is situated in the northern part of Illinois about 18 miles west of Lake Michigan. It lies in the Iowan and late Wisconsin glaciations, the latter covering the east three-fourths of the county. It has an area of 609.5 square miles.

During the Glacial period, snow and ice accumulated in the region of Labrador and to the west of Hudson Bay to such an extent that the mass pushed outward from these centers, chiefly southward, until a point was reached where it melted as rapidly as it advanced. In moving across the country the ice gathered up all sorts and sizes of material, including clay, silt, sand, gravel, small and large boulders, and even large masses of rock. Many of these were carried for hundreds of miles and the coarser materials were rubbed against surface rocks or against each other until largely ground into powder. When, thru the melting of the ice, the limit of advance was reached, the material carried by the glacier accumulated in a broad, undulating ridge or moraine. Much of the finer material was carried away in the drainage from the glacier and deposited on level outwash plains or over the flood plains of streams. When the ice melted more rapidly than the glacier advanced, the terminus of the glacier would recede and the material would be deposited somewhat irregularly over the area previously covered. This is known as the ground moraine, or intermorainal tract. A glacier receded and advanced a number of times, and with each advance another moraine was formed. The intermorainal tracts are now occupied chiefly by level, undulating, or slightly rolling plains.

The material transported by the glacier varied with the character of the rocks over which it passed. Granites, limestones, sandstones, shales, etc., were torn from their lodging places by the tremendous denuding power of the ice sheet and ground up together, the softer rocks disappearing first. A pressure of forty pounds per square inch is exerted by a mass of ice one hundred feet thick, and these ice sheets were hundreds or even thousands of feet in thickness. The materials carried along in the ice, especially the boulders and pebbles, became powerful agents for grinding and wearing away the surface over which the ice passed. Preglacial ridges and hills were rubbed down, valleys were filled with the debris, and the surface features were changed entirely. The mixture of material deposited by the glacier is known as boulder clay, till, glacial drift, or simply drift.

[1]J. G. Mosier, in charge of soil survey mapping; R. W. Dickenson and H. W. Stewart, in charge of field party; E. Van Alstine, in charge of soil analysis; H. J. Snider, in charge of experiment fields; L. H. Smith, in charge of publications.

THE GLACIATIONS OF McHENRY COUNTY

The first glacier to cover McHenry county was the Illinoisan, which covered all of Illinois except the northwest county, the southern part of Calhoun county, and the seven southernmost counties. The deposit left by this glacier was covered by the deposit of subsequent glaciers, and therefore does not form the surface soil at any place in McHenry county. The next glacier was the Iowan, which covered the northeastern part of the state, but most of the deposit left by this was also covered by deposits from some of the later glaciers.

Two glaciations form the present surface deposits: the Iowan, and the late Wisconsin. The Iowan occurs in the western part of the county and covers the larger part of Town 46 North, Range 5 East; the west half of Town 45 North, Range 5 East; approximately the west four tiers of sections in Town 44 North; and a small area in the southwest part of the county in Town 43 North, Range 5 East. Without doubt the early Wisconsin glacier covered part of McHenry county, but the late Wisconsin has buried the early Wisconsin drift so that it cannot be distinguished. The late Wisconsin contains a very extensive morainic system known as the Valparaiso moraine. The drift in the county is rarely less than 50 feet in thickness, and the average depth is not less than 200 feet.

Large areas of gravel outwash, formed by broad, shallow, swift streams flowing from the melting glacier, and mapped as terraces, are found in the west and southwest parts of the county. Another large area occurs to the south of Hebron, another east of Spring Grove, and still another south of Crystal Lake. These terraces furnish large quantities of gravel that are very valuable for road material and concrete work. Much of the area of the county is covered by a thin layer of loessial or wind-blown material.

PHYSIOGRAPHY AND DRAINAGE

The county varies widely in topography, the terrace and swamp lands being generally level, while the upland, especially that of the late Wisconsin glaciation, is decidedly rolling. The variations are principally due to the irregular deposition of glacial material in the moraines. The morainic areas are characterized by a peculiar billowy appearance produced by the large number of rounded knobs, and kettle-holes, or basin-like depressions, that vary in depth from 2 or 3 feet to 50 feet or more and in diameter from a few rods to 20 rods. A few lakes are found, the largest of which is the Pistakee, which extends over from Lake county. Some rock outcrop occurs in the western part of the county along the Kishwaukee river. Many swamps are found all over the county, and the kettle-holes on the moraines are frequently occupied by ponds. The western part of the county is drained by the Kishwaukee and its tributaries, while the eastern is drained by the Fox river and the Nippersink creek.

The altitudes of some places in McHenry county are as follows: Alden, 964 feet above sea level; Algonquin, 760; Big Foot Prairie, 950; Cary, 811; Chemung, 877; Coral, 875; Coyne, 885; Crystal Lake, 922; Greenwood, 820; Harmony, 910; Hartland, 924; Harvard, 935; Hebron, 931; Huntley, 888; Johnsburg, 790; Lawrence, 896; McHenry, 770; Marengo, 819; Richmond, 815; Ridgefield, 928; Ringwood, 837; Solon Mills, 792; Spring Grove, 781; Terra Cotta, 807; Union, 836; Woodstock, 916.

T 46 N

T 45 N

T 44 N

T 4. N

Map, Showing the Drainage Basins of McHenry County with Morainal, Terrace, Bottom-Land, and Swamp Areas

SOIL MATERIAL AND SOIL TYPES

The soils of the Iowan glaciation are not formed from the glacial drift left by that glacier, but from a deposit of wind-blown or loessial material varying in depth from 3 to 8 feet. The area covered by the late Wisconsin glacier does not have such a deep deposit of loess, and in some cases the soil was formed directly from glacial material. Usually, however, the glacial material is not found until a depth of 18 to 24 inches is reached. A large number of small areas of gravelly loam occur, many of which are not large enough to be shown on the map.

In general the glacial material of these moraines contains much more gravel than is found in the counties to the south. The outwash sand and gravel plains have been covered with finer material to a depth of 20 to 50 inches and constitute excellent soils. About one-fourth of the area of the county is swamp and

bottom-land. The accumulation of organic matter on this area has gone on to such an extent that the soils are very rich in this constituent.

The soils of McHenry county are divided into the following classes:

(a) Upland Prairie Soils.—These are rich in organic matter. This land was originally covered with wild prairie grasses, the partially decayed roots of which have been the source of the organic matter. The flat prairie land contains a higher amount of this constituent than the undulating or rolling prairie, because the grasses and roots grew more luxuriantly there, and being saturated with water they were preserved from complete decay.

TABLE 1.—SOIL TYPES OF MCHENRY COUNTY, ILLINOIS

Soil type No.	Name of type	Area in square miles	Area in acres	Percent of total area
	(a) Upland Prairie Soils (700, 1000, 1200)			
-26	Brown silt loam	120.08	76,851	19.70
-60	Brown sandy loam	28.24	18,074	4.63
-90	Gravelly loam	4.73	3,027	.78
		153.05	97,952	25.11
	(b). Upland Timber Soils (700, 1000, 1200)			
-34	Yellow-gray silt loam	130.04	83,226	21.34
-35	Yellow silt loam	4.92	3,149	.81
-64	Yellow-gray sandy loam	43.82	28,045	7.19
-65	Yellow sandy loam	1.10	704	.18
		179.88	115,124	29.52
	(c) Terrace Soils (1500)			
1527	Brown silt loam over gravel	45.93	29,395	7.54
1526.4	Brown silt loam on gravel	6.81	4,358	1.12
1525	Black silt loam	1.67	1,069	.27
1566	Brown sandy loam over gravel	8.41	5,382	1.38
1560.4	Brown sandy loam on gravel	31.31	20,039	5.14
1536	Yellow-gray silt loam over gravel	13.85	8,864	2.27
1534.4	Yellow-gray silt loam on gravel	5.88	3,763	.96
1567	Yellow-gray sandy loam over gravel	1.37	877	.22
1564.4	Yellow-gray sandy loam on gravel	4.21	2,694	.69
1528	Brown-gray silt loam on tight clay	.03	19	.004
1590	Gravelly loam	1.00	640	.16
		120.47	77,100	19.75
	(d) Late Swamp and Bottom-Land Soils (1400)			
1450	Black mixed loam	104.45	66,848	17.14
1450.2	Black mixed loam on sand	6.48	4,147	1.06
1401	Deep peat	36.74	23,514	6.03
1402.2	Medium peat on sand	.78	499	.13
1454	Mixed loam	2.69	1,722	.44
		151.14	96,730	24.80
	(e) Miscellaneous			
	Water	4.21	2,694	.69
	Gravel pits	.77	493	.13
		4.98	3,187	.82
	Total area	609.52	390,093	100.00

W I S C O N S I N WEST SHEET

The upland prairie soils include some areas of recent timber growth where certain kinds of trees have spread over the prairie, but this forestation has not been of sufficient duration to produce the characteristic timber soils. These areas of greater or less width are found along the border of most timber tracts, so that the timber actually extends a little farther than the soil type would indicate.

(b) Upland Timber Soils.—These include a large part of the upland that was formerly covered with forests. These soils contain much less organic matter than the prairie soils because the large roots of dead trees added but little, and the surface accumulations of leaves, twigs, and fallen trees were burned by forest fires or suffered almost complete decay. The timber lands are divided chiefly into two classes—the undulating and the hilly areas.

(c) Terrace Soils.—These include outwash sand and gravel plains, bench lands or second bottom lands, formed by deposition from overloaded streams during the melting of the glacier and subsequent to that time. Finer deposits which were later made upon the coarse, gravelly material now constitute the soil.

(d) Late Swamp and Bottom-Land Soils.—These include the overflow lands, or flood plains of streams, and the very poorly drained lowlands where peats, peaty loams, and mucks have been formed. The organic matter of these soils is derived largely from swamp mosses with grasses as a secondary source.

(e) Miscellaneous.—This includes the area occupied by water, rock outcrops, and gravel pits.

Table 1 shows the area of each type of soil in McHenry county in square miles and in acres, and its percentage of the total area. The accompanying map shows the location and boundary lines of the various types, even down to areas of a few acres.

For explanations concerning the classification of soils and the interpretation of the map and tables the reader is referred to the first part of the Appendix to this report.

INVOICE OF PLANT FOOD IN McHENRY COUNTY SOILS

SOIL ANALYSIS

The composition reported in the accompanying tables is, for the more extensive types, the average of several analyses. These analyses, like most things in nature, show more or less variation, but for general purposes the averages may be considered sufficient to characterize the soil type.

The chemical analysis of a soil by the methods here employed gives the invoice of the total stock of the several plant-food materials actually present in the soil strata sampled and analyzed, but it should be understood that the rate of liberation, as explained in the Appendix, page 27, is governed by many factors.

THE SURFACE SOIL

In Table 2 are reported the amount of organic carbon, which is a measure of the organic matter, and the total quantities of nitrogen, phosphorus, sulfur, potassium, magnesium, and calcium contained in 2 million pounds of the surface soil (the plowed soil of an acre about 6⅔ inches deep) of each type in McHenry

county. Because of the inadequacy of information furnished by mere averages with respect to limestone content and soil acidity, these figures are not included in the tabulated results. For a more complete explanation of this point see note in the tables.

The variation among the different types of soil with respect to the content of important plant-food elements is very marked. For example, the deep peat contains, in the plowed soil of an acre, nearly 30 times as much nitrogen as does the yellow-gray sandy loam. Comparing the deep peat with the most common type in the county, we find about 18 times as much nitrogen in the deep peat as in the yellow-gray silt loam, while on the other hand the yellow-gray silt loam contains about 18 times as much potassium as is found in the deep peat. The supply of phosphorus in the surface soil varies from 580 pounds per acre in the yellow-gray sandy loam to 3,380 pounds in the mixed loam. A sulfur content of 5,500 pounds per acre is found in the deep peat, while in the yellow-gray sandy loam there are but 230 pounds of this element. The magnesium varies in the different types from 1,750 pounds to 20,320 pounds, and the calcium content ranges from 3,270 pounds to 70,780 pounds per acre.

It is important to note that some of the plant-food elements are present in very limited quantities as compared with crop requirements. Some simple computations are of interest in this connection. Assume, for example, that a four-field crop rotation of wheat, corn, oats, and clover yields 50 bushels of wheat per acre, 100 bushels of corn, 100 bushels of oats, and 4 tons of clover hay. It will be found that the most prevalent upland soil of McHenry county, the yellow-gray silt loam, does not contain enough total nitrogen in the plowed soil for the production of such yields to supply four rotations. With respect to phosphorus the condition differs only in degree, this soil containing no more of that essential element than would be required for ten crop rotations yielding at the rates suggested above. On the other hand the amount of potassium in the surface layer of this common soil type would be sufficient for more than 25 centuries if only the grain were sold, or for more than 400 years if the total crops should be removed from the land and nothing returned.

These general statements relating to the total quantities of these plant-food materials in the plowed soil of the most prevalent type in the county certainly emphasize the fact that the supplies of some of these necessary elements of fertility are extremely limited when measured by the needs of large crop yields for even one or two generations of people.

THE SUBSURFACE AND SUBSOIL

In Tables 3 and 4 are recorded the amounts of plant food in the subsurface and subsoil of the different types of soil in McHenry county. It should be remembered, however, that these supplies are of little value unless the top soil is kept rich. These tables also show great stores of potassium and only limited amounts of nitrogen and phosphorus, in agreement with the data for the corresponding surface samples.

Table 2.—Plant Food in the Soils of McHenry County, Illinois: Surface Soil

Average pounds per acre in 2 million pounds of surface soil (about 0-6⅔ inches)

Soil type No.	Soil type	Total organic carbon	Total nitrogen	Total phosphorus	Total sulfur	Total potassium	Total magnesium	Total calcium
	(a) Upland Prairie Soils (700, 1000, 1200)							
-26	Brown silt loam	49 570	4 500	1 190	730	35 760	5 670	8 700
-60	Brown sandy loam	38 050	3 380	970	640	30 140	4 990	6 800
-90	Gravelly loam	64 040	5 820	1 860	1 020	25 700	20 320	27 300
	(b) Upland Timber Soils (700, 1000, 1200)							
-34	Yellow-gray silt loam	21 280	1 990	750	460	34 160	3 030	6 140
-35	Yellow silt loam	25 140	1 940	760	240	28 720	7 360	12 020
-64	Yellow-gray sandy loam	13 890	1 210	580	230	28 970	2 010	4 580
-65	Yellow sandy loam	28 480	1 980	840	320	30 480	5 420	14 320
	(c) Terrace Soils (1500)							
-27	Brown silt loam over gravel	60 650	5 210	1 430	890	34 950	6 030	7 920
-26.4	Brown silt loam on gravel	52 080	4 600	1 290	790	31 190	6 080	8 700
-25	Black silt loam	130 190	12 740	2 600	1 850	28 650	13 390	66 760
-66	Brown sandy loam over gravel	33 460	2 850	1 040	590	25 230	3 350	3 270
-60.4	Brown sandy loam on gravel	34 620	2 830	1 050	610	25 380	1 750	4 870
-36	Yellow-gray silt loam over gravel	28 400	2 850	1 170	510	36 630	3 230	6 650
-34.4	Yellow-gray silt loam on gravel	26 460	2 300	840	340	33 900	3 820	4 720
-67	Yellow-gray sandy loam over gravel	22 160	1 980	760	320	32 800	3 600	6 560
-64.4	Yellow-gray sandy loam on gravel	20 640	1 700	840	300	29 160	1 960	5 760
-28	Brown-gray silt loam on tight clay	74 380	7 180	1 420	1 020	35 680	2 860	7 140
-90	Gravelly loam	61 420	6 000	1 800	1 400	25 840	8 880	60 860
	(d) Late Swamp and Bottom-Land Soils (1400)							
-50	Black mixed loam	132 380	12 150	2 430	2 070	24 640	8 590	53 740
-50.2	Black mixed loam on sand	75 460	6 840	1 160	1 240	21 840	2 780	24 260
-01	Deep peat[1]	235 710	35 990	1 830	5 500	1 820	3 810	26 950
-02.2	Medium peat on sand[1]	278 560	24 040	1 190	5 030	6 930	3 830	41 520
-54	Mixed loam	160 900	16 000	3 380	2 680	23 840	10 680	70 780

Limestone and soil acidity

In connection with these tabulated data it should be explained that the figures on limestone content and soil acidity are omitted not because of any lack of importance of these factors, but rather because of the peculiar difficulty of presenting in general averages adequate information concerning the limestone requirement. The limestone requirement for soils is extremely variable. It may vary from farm to farm, and even from field to field. Therefore no attempt is made to include limestone content or the soil acidity present. The need for limestone should be determined on every farm and for each field individually. Fortunately this can be easily done by the simple tests described in the Appendix to this report, page 29.

[1]Amounts reported are for 1 million pounds of deep peat and medium peat.

TABLE 3.—PLANT FOOD IN THE SOILS OF MCHENRY COUNTY, ILLINOIS: SUBSURFACE SOIL

Average pounds per acre in 4 million pounds of subsurface soil (about 6⅔–20 inches)

Soil type No.	Soil type	Total organic carbon	Total nitrogen	Total phosphorus	Total sulfur	Total potassium	Total magnesium	Total calcium	Limestone and soil acidity
	(a) Upland Prairie Soils (700, 1000, 1200)								
-26	Brown silt loam	50 580	4 790	1 850	780	74 380	15 370	17 690	
-60	Brown sandy loam	44 040	3 840	1 640	1 080	70 060	16 080	64 600	
	(b) Upland Timber Soils (700, 1000, 1200)								
-34	Yellow-gray silt loam	17 900	1 940	1 610	580	73 460	11 220	15 680	
-35	Yellow silt loam	26 760	2 160	1 400	400	60 680	16 800	41 680	of any lack of import-
-64	Yellow-gray sandy loam	17 930	1 600	1 350	350	61 280	8 930	13 200	ance of these factors,
-65	Yellow sandy loam	21 280	1 560	1 600	240	62 160	21 240	48 280	but rather
	(c) Terrace Soils (1500)								the peculia presenting averages formation limestone
-27	Brown silt loam over gravel	52 460	4 970	1 980	960	73 830	8 340	15 200	The limestone require-
-26.4	Brown silt loam on gravel	59 800	5 320	2 230	1 170	65 280	10 730	14 040	ment for soils is ex-
-25	Black silt loam	80 680	7 680	3 140	1 520	68 440	26 960	62 000	tremely variable. It may
-66	Brown sandy loam over gravel	43 400	4 060	1 660	1 000	49 380	4 080	5 800	vary from farm to farm,
-60.4	Brown sandy loam on gravel	41 880	3 450	1 880	890	48 310	6 120	9 050	and even from field to
-36	Yellow-gray silt loam over gravel	18 500	2 280	2 300	440	75 260	11 060	11 660	field. Therefore no at-
-34.4	Yellow-gray silt loam on gravel	20 640	2 240	1 640	400	68 880	9 360	13 040	tempt is made to include
-67	Yellow-gray sandy loam over gravel	18 960	2 160	1 440	200	72 080	10 600	10 080	
-64.4	Yellow-gray sandy loam on gravel	20 320	1 960	1 520	600	60 160	6 680	8 880	
-28	Brown-gray silt loam on tight clay	31 200	2 840	1 120	1 000	78 200	7 720	13 760	
	(d) Late Swamp and Bottom-Land Soils (1400)								
-50	Black mixed loam	136 700	11 590	4 000	2 250	60 140	15 160	48 120	
-50.2	Black mixed loam on sand	16 400	1 080	840	40	48 760	3 560	9 280	
-01	Deep peat[1]	943 430	68 470	2 230	10 550	2 400	7 720	53 930	
-02.2	Medium peat on sand[1]	553 360	40 200	1 960	8 540	14 300	4 920	63 020	port, page 29.
-54	Mixed loam	164 720	16 040	5 360	2 840	43 960	19 680	209 480	

[1]Amounts reported are for 2 million pounds of deep peat and medium peat.

Table 4.—Plant Food in the Soils of McHenry County, Illinois: Subsoil
Average pounds per acre in 6 million pounds of subsoil (about 20-40 inches)

Soil type No.	Soil type	Total organic carbon	Total nitrogen	Total phosphorus	Total sulfur	Total potassium	Total magnesium	Total calcium	Limestone and soil acidity
	(a) Upland Prairie Soils (700, 1000, 1200)								
-26	Brown silt loam	29 170	3 040	2 530	900	104 000	52 560	86 010	
-60	Brown sandy loam	25 680	2 790	2 130	900	118 620	73 380	175 020	
	(b) Upland Timber Soils (700, 1000, 1200)								
-34	Yellow-gray silt loam	15 930	1 930	2 830	720	110 180	24 710	63 930	
-64	Yellow-gray sandy loam	13 760	1 560	2 300	280	97 360	24 640	35 580	
-65	Yellow sandy loam	24 600	1 380	2 700	300	96 060	46 380	208 740	but rather because of the peculiar difficulty of
	(c) Terrace Soils (1500)								
-27	Brown silt loam over gravel	27 590	3 140	2 850	800	103 730	33 560	32 630	
-26 4	Brown silt loam on gravel	29 580	2 900	2 520	500	84 180	20 140	20 700	
-25	Black silt loam	18 720	1 980	3 120	600	103 620	104 160	294 870	
-66	Brown sandy loam over gravel	28 200	2 610	2 220	900	78 300	8 220	19 170	
-60.4	Brown sandy loam on gravel	22 820	2 080	2 340	720	69 740	12 020	39 500	
-36	Yellow-gray silt loam over gravel	15 180	2 190	3 810	270	107 820	19 530	20 610	
-34 4	Yellow-gray silt loam on gravel	15 060	1 620	2 520	240	84 060	18 360	22 800	
-67	Yellow-gray sandy loam over gravel	19 980	2 040	2 640	540	127 800	54 720	139 020	
-64.4	Yellow-gray sandy loam on gravel	16 620	2 160	2 460	540	84 780	12 600	28 440	
-28	Brown-gray silt loam on tight clay	35 880	3 420	1 380	660	125 160	11 640	17 100	
	(d) Late Swamp and Bottom-Land Soils (1400)								
-50	Black mixed loam	55 010	4 460	4 490	2 000	94 880	19 930	105 180	
-50 2	Black mixed loam on sand	10 380	360	1 500	0	74 760	6 060	26 760	
-01	Deep peat [1]	1 395 230	65 880	2 310	19 260	7 590	9 170	70 320	
-02 2	Medium peat on sand	40 560	2 640	1 500	1 380	78 840	47 460	386 160	
-54	Mixed loam	85 560	6 960	3 660	2 100	62 760	44 040	439 260	

[1]Amounts reported are for 3 million pounds of deep peat.

DESCRIPTION OF INDIVIDUAL SOIL TYPES

(a) UPLAND PRAIRIE SOILS

The upland prairie soils of McHenry county cover an area of 153.05 square miles, or 25.11 percent of the area of the county. They are usually dark in color, owing to their large organic-matter content. The accumulation of organic matter in the prairie soils is due to the growth of prairie grasses that once covered them. The network of roots from these grasses was protected from complete decay by the imperfect aeration resulting from the covering of fine soil material and from the water it contained. On the native prairies the tops of these grasses were usually burned or decayed almost completely, so that the tops added very little organic matter to the soil.

Brown Silt Loam (726, 1026, 1226)

Brown silt loam, covering an area of 120.08 square miles, or 19.7 percent of the total area of the county, is one of the most extensive types in McHenry county. It occupies a considerable part of the less rolling land, some of which needs artificial drainage. The presence of kettle-holes makes complete drainage rather difficult, with the result that many small ponds are found. Small local areas of yellow-gray silt loam, sandy loam, gravelly loam, black mixed loam, and peat, too small to be shown on the map, are included in the type.

The surface soil, 0 to 6⅔ inches, is a brown silt loam, varying from yellowish brown on the more rolling areas to dark brown or black on the more nearly level and poorly drained tracts. In physical composition it varies to some extent but normally contains from 50 to 70 percent of the different grades of silt. In the low areas the proportion of clay is usually higher than on the more rolling parts, where a perceptible amount of sand may occur. The organic-matter content is somewhat variable but averages approximately 4.2 percent, or 42 tons per acre. The content is lower on the more rolling areas and higher on the more level parts. Where considerable erosion has occurred on the steep slopes of moraines, the type is mapped as yellow-gray silt loam although timber may never have grown there.

The natural subsurface is represented by a stratum varying from 6 to 20 inches in thickness. This variation is due to differences in topography and to erosion, the stratum being thinner on the more rolling areas. Less organic matter has accumulated on these areas than on the more level tracts and it disappears more rapidly with depth. In physical composition the subsurface varies in the same manner as the surface, but normally contains a slightly larger amount of clay and a smaller amount of organic matter. The organic-matter content of the stratum sampled (6⅔ to 20 inches) averages about 2.2 percent, varying from 1.8 to 2.8 percent. In color the subsurface varies from dark brown to light yellowish brown, becoming lighter with depth.

The natural subsoil begins at a depth of 12 to 20 inches and extends to an indefinite depth, but for analysis it is sampled to a depth of 40 inches. It varies from a yellow to a drabbish yellow clayey material usually made up of glacial drift. In some of the flat areas, however, where material has washed in from the surrounding parts, the drift is not reached at a depth of 40 inches. In some

places the stratum of glacial gravel beneath the loessial material is very evident and interferes in the collecting of samples.

Treatment.—Altho brown silt loam is fairly well supplied with organic matter, continuous cropping and the removal of practically all the crop residues will gradually reduce the amount until this, with its nitrogen, becomes the limiting factor in crop yields. On many farms or on parts of farms, this condition has already been reached.

In the management of this type, it is essential that manure or crop residues, including legumes, should be returned to the soil in the most practical and advantageous way. No form of organic matter should be burned. In live-stock farming the manure should be applied to the soil as soon as possible after it is produced, in order to avoid loss. Limestone and phosphorus should usually be applied to soil of this type. For results secured in field experiments on brown silt loam, see page 38 of the Supplement.

Brown Sandy Loam (960, 1060)

Brown sandy loam occurs principally in the southern part of the county and covers an area of 28.24 square miles, or 4.63 percent of the total area of the county. The sand of the type is derived very largely from glacial material. The type varies in topography from almost flat to decidedly rolling.

The surface soil, 0 to 6⅔ inches, consists of a brown sandy loam varying in color from a light or yellowish brown to a dark brown or even to a black. The sand content varies, being most abundant in the small patches that have been produced largely by the action of the wind. The organic-matter content is about 3 percent, or 30 tons per acre.

The subsurface, 6⅔ to 18 or 20 inches, consists of a brown to a yellowish brown sandy loam varying in the same manner as the surface soil. The organic-matter content is about 1.9 percent, or 38 tons per acre.

The subsoil is variable, in some places being made up of boulder clay while in others it is a yellowish sand, a clayey sand, or a sandy clay.

Treatment.—In general the type is sufficiently rolling for good drainage. It requires for its improvement the large use of organic matter, applied both as manure and as crop residues. This soil, being loose and better aerated than brown silt loam, suffers greater loss of organic matter by oxidation; hence greater difficulty is experienced in maintaining the necessary supply. Crop residues, legume crops, and manure must constitute the chief materials by which the organic matter is maintained. Ground limestone should usually be applied at the rate of about 2 or 3 tons per acre. These applications should be made frequently enough to keep a supply in the soil, but need not be made oftener than every four or five years. Sometimes the subsurface is well stocked with limestone in which case the supply will be easy to maintain.

Gravelly Loam (790, 1090)

Gravelly loam usually occurs in small areas and is fairly well distributed over the county, altho none is found in the Iowan glaciation. The type covers

an area of 3,027 acres. It is of very little importance from an agricultural standpoint, being adapted only for a low grade of pasture land.

(b) UPLAND TIMBER SOILS

The upland timber soils are deficient in organic matter owing to the fact that in forests the vegetable material from trees accumulates upon the surface and is either burned or suffers almost complete decay. Grasses, which furnish large amounts of humus-forming roots, do not grow to any extent. Moreover, the organic matter that had accumulated before the timber began growing is removed thru various decomposition processes, with the result that in these soils generally the nitrogen and organic-matter contents have become too low for the best growth of farm crops. The total area of upland timber soils in the county is 179.88 square miles, or 29.52 percent of the area of the county.

Yellow-Gray Silt Loam (734, 1034, 1234)

Yellow-gray silt loam is the most extensive soil type in McHenry county, covering an area of 130.04 square miles, or 21.34 percent of the total area of the county. While this type is confined chiefly to the more rolling parts of the moraines, it is also found irregularly distributed over other parts of the county.

The surface soil, 0 to 6⅔ inches, is a gray or yellowish gray silt loam, incoherent and mealy, but not granular. It varies greatly in physical composition, owing to the fact that in many places the thin covering of loess has been removed by erosion and a variable drift exposed. There are many local areas of sand or gravelly loam, but they are too small to be shown on the map. Likewise, there are many small areas of black mixed loam or black silt loam too small to be indicated on the map, that are found in kettle-hole depressions. The amount of organic matter in the surface stratum varies from 1.3 to 2.1 percent, with an average of about 1.8 percent, or 18 tons per acre. In some places erosion has reduced the content of organic matter much below the point of productiveness, and many small areas are decidedly yellow in color. On many of the steeper slopes much gravel and even small boulders are found.

The natural subsurface varies from 3 to 10 inches in thickness, being thinner on the more rolling areas. In color it is gray, grayish yellow, or yellow. It is somewhat pulverulent, but becomes more coherent and plastic with depth. The organic-matter content is about .8 percent, or 16 tons per acre in four million pounds of soil.

The subsoil is usually a yellow to a grayish yellow boulder clay. On the more level areas, however, the boulder clay may not be reached within 40 inches of the surface. The deeper subsoil frequently contains large amounts of limestone, as shown by the brisk effervescence when the hydrochloric acid test is applied.

Treatment.—In the management of yellow-gray silt loam, one of the essential points is the maintenance or increase of organic matter. This is even more necessary with this type than with brown silt loam, because this soil is naturally much more deficient in that constituent. The organic matter tends to prevent "running together," and on some of the more rolling areas lessens the washing. It gives better tilth to the soil under all conditions. As it decays, it supplies nitrogen and tends to liberate other plant food, as explained in the Appendix.

For adding organic matter to the soil the extensive use of the clovers, alfalfa, or other legumes is advised. These should be returned either directly to the soil along with crop residues, or in the manure produced in their consumption.

Because of the fact that in this type of soil in McHenry county carbonates are usually found in abundance in the subsoil and are sometimes present in the subsurface, it is difficult to prescribe a definite recommendation for the application of limestone that will apply to all locations. However, for the thrifty growth of such legumes as sweet clover and alfalfa limestone should be present in the surface soil in order to give the young plants a vigorous start. Therefore a moderate application of limestone, say 2 tons per acre, ought to prove profitable on all land of this type, and in some situations perhaps more than this amount could be applied to advantage, depending upon the depth to the naturally existing limestone.

Ultimately, for the best results in crop production the phosphorus content will need to be increased.

For results from practical field experiments on yellow-gray silt loam, see page 46 of the Supplement.

Yellow Silt Loam (735, 1035)

Yellow silt loam occurs principally along the Fox river in Town 43 North, Range 8 East, and in the northeast part of Town 44 North, Range 7 East. The type covers 3,149 acres, or less than one percent of the area of the county.

The surface soil, 0 to 6⅔ inches, is a yellow or yellowish gray silt loam, which usually contains some sand or gravel. This stratum is frequently formed from glacial drift, the loess having been removed by erosion. Owing to its derivation it varies a great deal in physical composition. The organic-matter content is about 2.3 percent, or 23 tons per acre.

The natural subsurface varies from 3 to 10 inches in thickness and is composed chiefly of a yellow or yellowish gray silt loam, but may vary from this to boulder clay and even to a very gravelly form of boulder clay. The organic-matter content of the stratum sampled (6⅔ to 20 inches) is about .9 percent.

The subsoil is made up of boulder clay, with about .4 percent of organic matter.

Treatment.—One of the best uses to which this type can be put is permanent pasture. As a rule, it cannot be satisfactorily cropped in ordinary rotations but it may be used very successfully for long rotations with pasture or meadow much of the time. Where limestone is naturally lacking in the upper portion of the soil, this material may well be used for the legumes in the rotation, or even as a top dressing to encourage their growth in pastures. Where this type has been long cultivated and thus exposed to surface washing, it is particularly deficient in nitrogen. Indeed, on such land the low supply of nitrogen is the factor that first menaces the growth of grain crops. Nitrogen is to be obtained from the air thru the growth of leguminous crops.

Yellow-Gray Sandy Loam (764, 1064)

Yellow-gray sandy loam occurs in many irregular areas all over the county. The total area covered by this type is 43.82 square miles, or 7.19 percent of

the area of the county. Its topography is about the same as that of the yellow-gray silt loam, and it occurs on morainal areas somewhat similar to that type.

The surface soil, 0 to 6⅔ inches, is a gray or yellowish gray sandy loam, varying rather widely in its physical composition. In some localities it contains a considerable percentage of gravel, sufficient in many cases to form a gravelly loam, but the areas are too small to be shown on the map. The organic-matter content is approximately 1.2 percent, or 12 tons per acre.

The natural subsurface is represented by a stratum from 4 to 10 inches in thickness. It varies in physical composition the same as the surface, except that it contains more gravel. It is frequently formed from the glacial drift. The stratum sampled (6⅔ to 20 inches) contains about .8 percent of organic matter.

The subsoil is made up of glacial drift and contains about .4 percent of organic matter. The surface and subsurface are usually acid, altho the subsoil sometimes contains a considerable amount of limestone.

Treatment.—Where clover continues to fail on this type, applications of 2 tons of ground limestone can well be made for the purpose of increasing the growth of legumes. The content of organic matter and of nitrogen must be largely increased, since this type is one of the lowest in organic matter found in the county. The phosphorus content is very low and should therefore be built up in order to obtain the best results. Sweet clover is an excellent crop to grow on this type because of the large amount of organic matter that it supplies.

Yellow Sandy Loam (1065)

Yellow sandy loam occurs in the very rolling and sandy area of the county. It occupies 704 acres.

The surface soil, 0 to 6⅔ inches, is in the main a yellow sandy loam altho it varies considerably in physical composition, in places containing some gravel. The type contains a larger amount of organic matter than does the yellow-gray sandy loam because of the fact that it has never been under cultivation. The organic-matter content is 2.4 percent, or twice the amount present in the preceding type.

The subsurface also varies in physical composition, being rather gravelly in some places.

The subsoil corresponds in physical composition to the surface and subsurface.

Treatment.—This type is adapted only to pasture, and legumes should be grown on it. Sweet clover is probably one of the best plants for the purpose. Limestone is likely to be beneficial.

(c) TERRACE SOILS

Terrace soils usually occur along streams. They were formed at a time when the streams, owing to melting glacier ice, were much larger than they are at present, and carried large amounts of coarse material, such as sand and gravel. Upon any decrease in their velocity, these overloaded streams deposited debris along their courses. This resulted in the partial filling of the valley and the formation of what are now the terraces, bench lands, or second bottom lands.

Finer material later deposited over this sand and gravel forms the present soil. When the streams became reduced to their normal size after the glacier had melted, they began cutting down thru this deposit, and the beds of the streams are now so low that the terraces, or benches, do not overflow.

Several gravel outwash plains occur which were formed by the sand and gravel that was deposited when water from the melting ice spread over large level areas. These plains were later covered by the finer material which forms the present soil.

Brown Silt Loam over Gravel (1527)

Brown silt loam over gravel occurs in four large areas in the county, one near Hebron, one near Harvard, one north of Franklinville, and the other just west of Rush creek. The type covers 45.93 square miles, or 7.54 percent of the area of the county.

The surface soil, 0 to 6⅔ inches, varies from a brown to a very dark brown silt loam which frequently contains some sand, altho not enough to cause it to be classified as a sandy loam. While the topography is usually flat, some slight undulations occur which were probably produced by the channels of the flooded streams. The surface soil contains about 5 percent of organic matter, or 50 tons per acre. It varies from 4 to 6.5 percent.

The natural subsurface stratum varies from 7 to 16 inches in thickness. The organic-matter content of the stratum as sampled (6⅔ to 20 inches) is about 2.3 percent, or 46 tons per acre. In physical composition it is about the same as the surface.

The subsoil is a yellow to a mottled yellow silt loam with some gravel appearing in the deeper subsoil. The depth to gravel, however, varies from 36 to 54 inches or more.

Treatment.—All strata are pervious to water, so that drainage is very good, provided a sufficient outlet is obtained. The gravel is so far from the surface that crops do well even in years of some drouth. This is one of the best of the terrace types. In the improvement of this type, limestone, phosphorus, and organic matter should be provided as recommended for the brown silt loam of the upland (see page 11).

Brown Silt Loam on Gravel (1526.4)

Brown silt loam on gravel represents a type in which the fine soil material is less than 30 inches in thickness, or in which the gravel is within 30 inches of the surface. The principal areas are found in the broad valleys of Rush creek and the north branch of the Kishwaukee. The total area is 4,358 acres, or 1.12 percent of the area of the county.

The surface soil, 0 to 6⅔ inches, is a brown silt loam containing some sand. Organic matter is present to the amount of about 4.8 percent, or 48 tons per acre.

The natural subsurface stratum varies from 8 to 12 inches in thickness, and is a brown to light yellowish brown silt loam containing gravel which in some cases amounts to as much as 5 percent. The organic-matter content of the stratum sampled (6⅔ to 20 inches) is about 2.6 percent, or 52 tons in four million pounds of soil.

The subsoil is about the same as the subsurface until gravel is reached. The gravel consists of a mixture of fine gravel and sand with some of the finer soil constituents.

Treatment.—This soil type is well drained, but because of the nearness of gravel to the surface it does not resist drouth well. For this reason early maturing crops are desirable. In the management of the type care must be taken to maintain the supply of organic matter, since this constituent is so important in the conservation of moisture. An application of 2 or 3 tons per acre of limestone is recommended in order that clover or alfalfa may be grown.

Black Silt Loam (1525)

Black silt loam occurs in the lower and more poorly drained parts of the terrace. Either the gravel is so deep or the outlet is so poor that drainage does not take place readily. The type covers an area of 1,069 acres.

The surface soil, 0 to 6⅔ inches, is a black silt loam becoming in some cases so heavy as to form a black clayey silt loam. It contains about 10.5 percent of organic matter, or 105 tons per acre.

The natural subsurface soil is a black clayey silt loam and extends to a depth of 18 to 20 inches. The stratum sampled (6⅔ to 20 inches) contains approximately 2.8 percent of organic matter.

The subsoil is represented by a clayey stratum varying in color from a pale yellow to a drabbish yellow. It contains about .5 percent of organic matter.

Treatment.—All strata are pervious to water so that drainage is effected very readily when proper tiling is done. In the management of this type about the only consideration at present is the maintenance of good physical condition by means of active organic matter. Usually a good supply of phosphorus and limestone is present.

Brown Sandy Loam over Gravel (1566)

Brown sandy loam over gravel is found principally in the south third of the county. It covers an area of 8.41 square miles or 5,382 acres. The topography is flat to slightly undulating.

The surface soil, 0 to 6⅔ inches, is a brown sandy loam with about 2.9 percent of organic matter, or 29 tons per acre.

The subsurface is a brown sandy loam containing about 1.9 percent of organic matter. In physical composition it is practically the same as the surface soil, but it becomes yellow at about 16 to 18 inches.

The subsoil is a yellow sandy silt which in some cases becomes gravelly at 36 inches.

Treatment.—The very low nitrogen content, which is characteristic of a sandy soil, calls for the liberal use of legume crops; and the chemical analysis indicates the need of limestone in order to insure a thrifty growth of the legumes. An application of about 2 tons per acre of ground limestone is suggested. The phosphorus content is also low and doubtless as times goes on, under a system that produces larger crops, phosphorus will become a limiting element that will need to be replenished.

Brown Sandy Loam on Gravel (1560.4)

Brown sandy loam on gravel occurs very largely in the southern part of the county in the vicinity of Marengo. Another large area occurs south of Crystal Lake. The type covers an area of 31.31 square miles, or 5.14 percent of the area of the county. The topography is flat.

The surface soil, 0 to 6⅔ inches, is a brown sandy loam varying in sand content and containing from 2 to 3 percent of gravel. The organic-matter content averages 2.5 percent.

The subsurface stratum contains about 1.7 percent of organic matter and a noticeable amount of gravel.

The gravel subsoil begins at a depth of 16 to 28 inches and consists of a mixture of coarse sand and fine gravel. Comparatively small amounts of the finer soil constituents are present in this gravel. The nearness of gravel to the surface reduces the moisture-holding capacity of this type, with the result that crops may suffer from drouth.

Treatment.—The type is sometimes acid in the upper strata but occasionally the subsoil contains a considerable amount of limestone. In the management of this soil the same recommendations apply as those given in the discussion of the preceding type.

Yellow-Gray Silt Loam over Gravel (1536)

Yellow-gray silt loam over gravel is found in various parts of the county but more particularly along the lower Fox river, in the Iowan glaciation in the northwest part of the county, and in Towns 45 and 46 North, Range 7 East. The total area is 13.85 square miles.

The surface soil, 0 to 6⅔ inches, is a brownish yellow or grayish yellow silt loam, verging toward yellow sandy loam in some localities. The organic-matter content averages 2.4 percent, or 24 tons per acre.

The natural subsurface is a stratum of a yellowish or grayish yellow color. It varies from 8 to 10 inches in thickness. The organic-matter content of the stratum sampled (6⅔ to 20 inches) is about .8 percent.

The subsoil is a yellow silt to clayey silt.

Treatment.—The nitrogen in this soil is very low, and methods looking toward its replenishment should be adopted at once. Applications of limestone amounting to 2 or 3 tons per acre should be made, and this material will probably need to be replenished every four or five years in order to encourage the growth of legumes. The organic-matter content should be maintained by turning under crop residues and all forms of available organic material. The phosphorus supply also is insufficient and in the course of time, if not immediately, this element should be applied.

Yellow-Gray Silt Loam on Gravel (1534.4)

Yellow-gray silt loam on gravel is found widely distributed thruout the county, but covers a total area of only 5.88 square miles.

The surface soil, 0 to 6⅔ inches, is a brownish yellow or yellowish gray silt loam containing about 2.3 percent of organic matter.

The subsurface is represented by a stratum from 7 to 10 inches in thickness. The organic-matter content of the stratum sampled (6⅔ to 20 inches) is about .9 percent.

The subsoil is a yellowish clayey silt which in some cases passes into gravel at 30 to 38 inches.

Treatment.—This soil is similar in composition to that of the preceding type. It is low in organic matter, nitrogen, and phosphorus, and limestone is absent. In order to improve it, therefore, an application of 2 or 3 tons of limestone per acre should be made, and legumes should be grown either to be turned back into the soil directly or to be fed to stock and the manure applied. The phosphorus content should be increased by applying from ½ to 1 ton per acre of raw rock phosphate in a four- or five-year rotation.

Yellow-Gray Sandy Loam over Gravel (1567)

Yellow-gray sandy loam over gravel is found principally along the Fox river. It covers an area of 877 acres.

The surface soil, 0 to 6⅔ inches, is a gray to grayish yellow sandy loam with about 1.9 percent of organic matter, or 19 tons per acre.

The natural subsurface consists of a yellow sandy loam varying from 6 to 10 inches in thickness. The organic-matter content of the stratum sampled (6⅔ to 20 inches) is approximately .8 percent.

The subsoil varies from a yellow sandy silt to a yellow sand. The former is much more common than the latter.

Treatment.—The type is rather low in several elements of plant food. Legumes should be grown in order to increase the nitrogen, as the chemical analysis shows the total amount of this element to be less than 2,000 pounds in the plowed soil. The subsoil usually contains a considerable amount of limestone; but since this material is lacking in the surface and subsurface, an application of about 2 tons per acre is recommended. The phosphorus supply is likewise very meagre, and before this becomes a limiting element it should be increased by applications of a half ton or more of raw rock phosphate to the acre every four or five years.

Yellow-Gray Sandy Loam on Gravel (1564.4)

Yellow-gray sandy loam on gravel occurs in various parts of the county, but not in any large areas. It is always mixed more or less with other types. The total area amounts to 2,694 acres.

The surface soil, 0 to 6⅔ inches, is a yellow or grayish yellow sandy loam containing about 1.8 percent of organic matter, or 18 tons per acre.

The natural subsurface soil is represented by a stratum 6 to 10 inches in thickness. The stratum sampled (6⅔ to 20 inches) contains about .9 percent of organic matter.

The subsoil is a yellowish sandy silt which passes into gravel at a depth of 18 to 26 inches.

Treatment.—This soil, as is characteristic of a sandy loam, is very low in nitrogen (less than 2,000 pounds per acre being present in the plowed soil) and organic matter. The stock of phosphorus is likewise decidedly low. In the management of this soil, therefore, legumes should be grown and all available

manure should be applied. Analysis shows no limestone above the subsoil; therefore crushed limestone should be applied at the rate of about 2 tons per acre. Phosphorus may be supplied in the form of finely ground raw rock phosphate at the rate of ½ to 1 ton per acre.

Brown-Gray Silt Loam on Tight Clay (1528)

Only a very small area of brown-gray silt loam on tight clay, 19 acres in extent, occurs in the county.

The surface soil, 0 to 6⅔ inches, is a brown silt loam containing about 6.4 percent of organic matter.

The subsurface is a gray silt loam containing approximately 1.3 percent of organic matter.

The subsoil consists of a tight clay, rather impervious.

Treatment.—According to the analysis, limestone is absent. Therefore this material should be applied at the rate of about 2 tons per acre. The growing of sweet clover is recommended. This may serve to some extent to break up the clay of the subsoil.

Gravelly Loam (1590)

Gravelly loam does not form an important type agriculturally, covering as it does only one square mile.

The surface soil contains about 5.3 percent of organic matter. The type is of value only for pasture.

(d) LATE SWAMP AND BOTTOM-LAND SOILS

Black Mixed Loam (1450)

Black mixed loam is the most common of the swamp types, and is distributed all over the county. The areas vary in size from those that are several square miles in extent to numberless areas too small to map. The type covers an area of 104.45 square miles, or 17.14 percent of the total area of the county.

The surface soil, 0 to 6⅔ inches, is a black soil varying from a peat on one hand to a clay loam or a black sandy loam on the other. These different types are so small in extent that it is practically impossible to show them on the map. Hence the entire area is mapped as the black mixed loam. The plowed soil contains about 11.4 percent of organic matter, or 114 tons per acre.

The natural subsurface is represented by a stratum 8 to 12 inches in thickness. The stratum sampled (6⅔ to 20 inches) contains about 5.9 percent of organic matter, or 118 tons per acre.

The subsoil is a yellowish drab or drab silty clay or clayey silt which contains about 1.6 percent of organic matter.

Treatment.—All strata are pervious to water, so that artificial drainage may result in transforming this land into very productive soil. It is well supplied with phosphorus and nitrogen. Limestone is often abundant in all strata but sometimes it may be totally absent. In such exceptional cases the artificial application of this material should be made. This land is used principally for pasture because of the fact that it has not yet been sufficiently drained for cropping.

Black Mixed Loam on Sand (1450.2)

Black mixed loam on sand occurs in the vicinity of Marengo and extends into Boone county to the west. It covers an area of 6.48 square miles.

The surface soil, 0 to 6⅔ inches, varies from a loam to a sandy loam. It contains about 6.5 percent of organic matter.

The subsurface is a black to grayish sand with about .7 percent of organic matter.

The subsoil is a gray or yellow sand.

Treatment.—Provision for drainage, which is the first requirement of this land, has already been made in the principal tract of this type. Cropping, however, has been pretty largely attended by failure. This kind of soil is not constituted to endure drouth, and successful cropping will therefore depend much upon the time of maturity of crops grown, the distribution of rainfall, and the height of the water table. Early maturing crops, such as winter wheat and rye, provided conditions at time of seeding in the autumn are sufficiently favorable to insure germination, are much more likely to succeed than a crop like corn.

A definite prescription for the application of fertilizing materials is scarcely warrantable at this time because this type of soil is so peculiar that reliable information must be based very largely upon actual experience.

Deep Peat (1401)

Deep peat is distributed thruout the county and covers 36.74 square miles, or 6.03 percent of the total area of the county.

The surface soil, 0 to 6⅔ inches, is a black peat containing about 75 percent of organic matter, or 375 tons per acre.

The subsurface soil contains about 81 percent of organic matter.

The subsoil contains about 80 percent of organic matter.

Treatment.—Drainage is the first requirement of this type. This in many cases is rather difficult to secure because tiles cannot be laid to good advantage in peat on account of irregular settling and the consequent displacement of the line. This difficulty may be partly overcome by placing the tiles upon boards laid in the bottom of the ditch, altho such a system cannot be regarded as permanent.

Where thoro drainage can be provided, either by the above method or by open ditches, very marked improvement can be made in the productive power of peat by the liberal use of potassium, which is by far the most deficient element. Farm manure and crop residues contain sufficient potassium to make their use very effective on deep peat soil; and with commercial potash salts at prohibitive prices, farm manure, corn stalks, straw, etc., must be utilized for the improvement of such soils.

The chemical analysis shows that limestone is not always present in the deep peat of McHenry county. When the simple tests described in the Appendix, page 29, indicate the absence of limestone, then this material should be applied at the rate of about 2 tons per acre.

For an account of field experiments on deep peat the reader is referred to page 49 of the Supplement.

Plate 9.—Hummocks on "Bog" Land Characteristic of Peat and Certain Other Swampy Soils after Pasturing

Medium Peat on Sand (1402.2)

Medium peat on sand occurs in low swampy places similar to those occupied by deep peat, but the conditions for the formation of this type have not been so favorable as for deep peat, and as a consequence the peaty material is less than 30 inches thick. The type covers 499 acres.

The surface soil, 0 to 6⅔ inches, contains about 48 percent of organic matter.

The subsurface is of about the same general character as the surface stratum.

The subsoil consists largely of sand, with only 1.2 percent of organic matter.

Treatment.—The type needs drainage and the application of potassium.

Mixed Loam (1454)

Mixed loam occurs as bottom land in different parts of the county, but usually in small areas. There are 1,722 acres of this type in the county.

The surface soil, 0 to 6⅔ inches, contains about 13.9 percent of organic matter and consists of a black mixed loam, the variability of which is produced by depositions during overflow.

The subsurface contains about 7.1 percent of organic matter.

The subsoil contains about 2.5 percent of organic matter.

The type is rich in nitrogen and phosphorus and in the area sampled has an abundance of limestone.

APPENDIX

EXPLANATIONS FOR INTERPRETING THE SOIL SURVEY

CLASSIFICATION OF SOILS

In order to intelligently interpret the soil maps, the reader must understand something of the method of soil classification upon which the survey is based. Without going far into details the following paragraphs are intended to furnish a brief explanation of the general plan of classification here used.

The unit in the soil survey is the soil type, and each type possesses more or less definite characteristics. The line of separation between adjoining types is usually distinct, altho sometimes one type grades into another so gradually that it is very difficult to draw the line between them. In such exceptional cases, some slight variation in the location of soil-type boundaries is unavoidable.

In establishing soil types several factors must be taken into account. These are: (1) the geological origin of the soil, whether residual, cumulose, glacial, eolial, alluvial, or colluvial; (2) the topography, or lay of the land; (3) the native vegetation, as forest or prairie grasses; (4) the depth and the character of the surface, the subsurface, and the subsoil, as to the percentages of gravel, sand, silt, clay, and organic matter which they contain, their porosity, granulation, friability, plasticity, color, etc.; (5) the natural drainage; (6) the agricultural value, based upon its natural productiveness; (7) the ultimate chemical composition and reaction.

Great Soil Areas in Illinois.—On the basis of the first of the above mentioned factors, namely, the geological origin, the state of Illinois has been divided into sixteen great soil areas with respect to their geological formation. The names of these areas are given in the following list along with their corresponding index numbers, the use of which is explained below. For the location of these geological areas, the reader is referred to the general map published in Bulletins 123 and 193.

100 *Unglaciated,* comprizing three areas, the largest being in the south end of the state
200 *Illinoisan moraines,* including the moraines of the Illinoisan glaciation
300 *Lower Illinoisan glaciation,* covering nearly the south third of the state
400 *Middle Illinoisan glaciation,* covering about a dozen counties in the west-central part of the state
500 *Upper Illinoisan glaciation,* covering about fourteen counties northwest of the middle Illinoisan glaciation
600 *Pre-Iowan glaciation,* but now believed to be part of the upper Illinoisan
700 *Iowan glaciation,* lying in the central northern end of the state
800 *Deep loess areas,* including a zone a few miles wide along the Wabash, Illinois, and Mississippi rivers
900 *Early Wisconsin moraines,* including the moraines of the early Wisconsin glaciation
1000 *Late Wisconsin moraines,* including the moraines of the late Wisconsin glaciation
1100 *Early Wisconsin glaciation,* covering the greater part of the northeast quarter of the state
1200 *Late Wisconsin glaciation,* lying in the northeast corner of the state
1300 *Old river bottom and swamp lands,* found in the older or Illinoisan glaciation
1400 *Late river bottom and swamp lands,* those of the Wisconsin and Iowan glaciations
1500 *Terraces,* formed by overloaded streams draining from the glaciers and gravel outwash plains
1600 *Lacustrine deposits,* formed by Lake Chicago or the enlarged Lake Michigan

Mechanical Composition of Soils.—The mechanical composition, or the texture, is a most important feature in characterizing a soil. The texture depends upon the relative proportions of the following physical constituents:

Organic matter: undecomposed and partially decayed vegetable material

Inorganic matter: clay, silt, fine sand, sand, gravel, stones.

Classes of Soils.—Based upon the relative proportion of the various constituents mentioned above, soils may be grouped into a number of well recognized classes. Following is a list of these classes, arranged according to their index numbers, the use of which is explained below.

Index Number Limits	Class Names
0 to 9	Peats
10 to 12	Peaty loams
13 to 14	Mucks
15 to 19	Clays
20 to 24	Clay loams
25 to 49	Silt loams
50 to 59	Loams
60 to 79	Sandy loams
80 to 89	Sands
90 to 94	Gravelly loams
95 to 97	Gravels
98	Stony loams
99	Rock outcrop

Naming and Numbering Soil Types.—The naming of soil types has been the subject of much discussion, and practice varies considerably in this matter. In this soil survey of Illinois a system of classification and naming has been adopted which is based upon the various considerations presented in the preceding paragraphs.

After texture, one of the most striking characteristics of a soil is the color. Therefore, in the naming of soils in Illinois, a combination of color and texture, together with other descriptive terms when necessary, has been adopted so that the name in itself carries a definite description of a given soil type; as for example, "gray silt loam on tight clay," or "brown silt loam over gravel." The use of the prepositions *on* and *over* serves to indicate the presence of certain substrata. When the surface soil is underlain with material such as sand, gravel, or rock, the word *over* is used if this material lies at a depth greater than 30 inches; if it is less than 30 inches, the word *on* is used.

For further identification of soil types a system of numbering, resembling somewhat the Dewey library system, has been adopted whereby each soil type is assigned a certain number. This number indicates at once the geological origin of the soil as well as its physical description. The digits of the order of hundreds represent the geological area where the soil is found, beginning at 100 with the unglaciated, and following in series in the order of the enumeration presented in the paragraph above headed *Great Soil Areas In Illinois.* The digits of the orders of units and tens represent the various kinds of soil such as are enumerated above in the list of soil classes. A modification of a soil type called a *phase* is designated in this system by a figure placed at the right of the decimal point. To illustrate the working of this numbering system, suppose a soil type bears the number 726.5. The number 7 indicates that this soil occurs in the Iowan glaciation, the 26 that it is a brown silt loam, and the .5 that rock is found less than 30 inches below the surface. These numbers are especially useful in designating small areas on the map and as a check in reading the colors.

A complete list of the soil types occurring in each county, along with their corresponding type numbers and a description of the area covered, will be found in the respective county soil reports.

SOIL SURVEY METHODS

Mapping the Soil Types.—In conducting the soil survey, the county constitutes the unit of working area. In order that the survey be thoroly truthworthy it is necessary that careful, well-trained men be employed to do the mapping. The work is prosecuted to the best advantage by working in parties of from two to four. Only such men are placed in charge of these parties as are thoroly experienced in the work and have shown themselves to be especially well qualified in training and ability.

The men must be able to keep their location exactly and to recognize the different soil types, with their principal variations and limits, and they must show these upon the maps correctly. A definite system is employed in checking up this work. As an illustration, one man will survey and map a strip 80 rods or 160 rods wide and any convenient length, while his associate will work independently on another strip adjoining this area, and if the work is correctly done the soil-type boundaries will match up on the line between the two strips.

An accurate base map for field use is absolutely necessary for soil mapping. The base maps are prepared on a scale of one inch to the mile, the official data of the original or subsequent land survey being used as a basis in their construction. Each surveyor is provided with one of these base maps, which he carries with him in the field; and the soil-type boundaries, together with the streams, roads, railroads, canals, and town sites are placed in their proper locations upon the map while the mapper is on the area. Each section, or square mile, is divided into 40-acre plots on the map, and the surveyor must inspect every ten acres and determine the type or types of soil composing it. The different types are indicated on the map by different colors, pencils for this purpose being carried in the field.

A small auger 40 inches long forms for each man an invaluable tool with which he can quickly secure samples of the different strata for inspection. An extension for making the auger 80 inches long is taken by each party, so that any peculiarity of the deeper subsoil layers may be studied. Each man carries a compass to aid in keeping directions. Distances along roads are measured by an odometer attached to the axle of the vehicle or by some other measuring device, while distances in the field away from the roads are determined by pacing, an art in which the men become expert by practice. The soil boundaries can thus be located with as high a degree of accuracy as can be indicated by pencil on the scale of one inch to the mile.

Sampling for Analysis.—After all the soil types of a county have been located and mapped, samples representative of the different types are collected for chemical analysis. For this purpose usually three strata are sampled; namely, the surface (0 to 6⅔ inches), the subsurface (6⅔ to 20 inches), and the subsoil (20 to 40 inches). These strata correspond approximately, in the common kinds of soil, to 2,000,000 pounds of dry soil per acre in the surface layer, and to two times and three times this quantity in the subsurface and the subsoil, respectively.

By this system of sampling we have represented separately three zones for plant feeding. The surface layer includes at least as much soil as is ordinarily turned with the plow. This is the part with which the farm manure, limestone, phosphate, or other fertilizer applied in soil improvement is incorporated, and which must be depended upon in large part to furnish the necessary plant food for the production of crops. Even a rich subsoil has little or no value if it lies beneath a worn-out surface, but if the fertility of the surface soil is maintained at a high point, then the strong, vigorous plants will have power to secure more plant food from the subsurface and subsoil.

PRINCIPLES OF SOIL FERTILITY

Probably no agricultural fact is more generally known by farmers and landowners than that soils differ in productive power. Even tho plowed alike and at the same time, prepared the same way, planted the same day with the same kind of seed, and cultivated alike, watered by the same rains and warmed by the same sun, nevertheless the best acre may produce twice as large a crop as the poorest acre on the same farm, if not, indeed, in the same field; and the fact should be repeated and emphasized that with the normal rainfall of Illinois the productive power of the land depends primarily upon the stock of plant food contained in the soil and upon the rate at which it is liberated, just as the success of the merchant depends primarily upon his stock of goods and the rapidity of sales. In both cases the stock of any commodity must be increased or renewed whenever the supply of such commodity becomes so depleted as to limit the success of the business, whether on the farm or in the store.

CROP REQUIREMENTS

Ten different elements of plant food are essential for the growth and formation of every plant. These elements are: *carbon, oxygen, hydrogen, nitrogen, phosphorus, sulfur, potassium, magnesium, calcium, and iron;* and they are represented by the chemical symbols: C, O, H, N, P, S, K, Mg, Ca, and Fe. Some seasons in central Illinois are sufficiently favorable to allow the production of at least 50 bushels of wheat per acre, 100 bushels of corn, 100 bushels of oats, and 4 tons of clover hay. When such crops are not produced under favorable seasonal conditions, the failure is due to unfavorable soil condition, which may

TABLE A.—PLANT FOOD IN WHEAT, CORN, OATS, AND CLOVER

Produce: Kind	Produce: Amount	Nitrogen	Phosphorus	Sulfur	Potassium	Magnesium	Calcium	Iron
		lbs.	*lbs.*	*lbs.*	*lbs.*	*lbs.*	*lbs.*	*lbs.*
Wheat, grain	1 bu.	1.42	.24	.10	.26	.08	.02	.01
Wheat straw	1 ton	10.00	1.60	2.70	18.00	1.60	3.80	.60
Corn, grain	1 bu.	1.00	.17	.08	.19	.07	.01	.01
Corn stover	1 ton	16.00	2.00	2.42	17.33	3.33	7.00	1.60
Corn cobs	1 ton	4.00	.....	.....	4.00	.....	.....	.....
Oats, grain	1 bu.	.66	.11	.06	.16	.04	.02	.01
Oat straw	1 ton	12.40	2.00	4.14	20.80	2.80	6.00	1.12
Clover seed	1 bu.	1.75	.50	.....	.75	.25	.13	.....
Clover hay	1 ton	40.00	5.00	3.28	30.00	7.75	29.25	1.00

result from poor drainage, poor physical condition, or an actual deficiency of plant food.

Table A shows the plant-food requirements of some of our most common field crops with respect to the seven elements furnished by the soil. The figures show the weight in pounds of the various elements contained in a bushel or in a ton, as the case may be. From these data the amount of any element removed from an acre of land by a crop of a given yield can easily be computed.

It needs no argument to show that the continuous removal of such quantities of plant food without provision for their replacement must result sooner or later in soil depletion.

PLANT-FOOD SUPPLY

Of the ten elements of plant food, three *(carbon, oxygen,* and *hydrogen)* are secured from air and water, and seven from the soil. *Nitrogen,* one of these seven elements obtained from the soil by all plants, may also be secured from the air by one class of plants (legumes), in case the amount liberated from the soil is insufficient; but even these plants (which include only the clovers, peas, beans, and vetches among our common agricultural plants) are dependent upon the soil for the other six elements *(phosphorus, potassium, magnesium, calcium, iron, and sulfur),* and they also utilize the soil nitrogen so far as it becomes soluble and available during their period of growth.

TABLE B.—PLANT-FOOD ELEMENTS IN MANURE, ROUGH FEEDS, AND FERTILIZERS

Material	Pounds of plant food per ton of material		
	Nitrogen	Phosphorus	Potassium
Fresh farm manure	10	2	8
Corn stover	16	2	17
Oat straw	12	2	21
Wheat straw	10	2	19
Clover hay	40	5	30
Cowpea hay	43	5	33
Alfalfa hay	50	4	24
Sweet clover (water-free basis)[1]	80	8	28
Dried blood	280	...	...
Sodium nitrate	310	...	...
Ammonium sulfate	400	...	...
Raw bone meal	80	180	...
Steamed bone meal	20	250	...
Raw rock phosphate	...	250	...
Acid phosphate	...	125	...
Potassium chlorid	...	...	850
Potassium sulfate	...	...	850
Kainit	...	...	200
Wood ashes[2]	...	10	100

[1]Young second year's growth ready to plow under as green manure.
[2]Wood ashes also contain about 1,000 pounds of lime (calcium carbonate) per ton.

The vast difference with respect to the supply of these essential plant food elements in different soils is well brought out in the data of the Illinois soil survey. For example, it has been found that the nitrogen in the surface 6⅔ inches, which represents the plowed stratum, varies in amount from 180 pounds per acre to nearly 33,000 pounds. In like manner the phosphorus content varies from about 420 pounds to 4,900 pounds, the potassium ranges from 1,530 pounds to about 58,000 pounds. Similar variations are found in all of the other essential plant food elements of the soil.

With these facts in mind it is easy to understand how a deficiency of one of these elements of plant food may become a limiting factor of crop production. When an element becomes so reduced in quantity as to become a limiting factor of production, then we must look for some outside source of supply. Table B is presented for the purpose of furnishing information regarding the quantity of plant food contained in some of the materials most commonly used as sources of plant-food supply.

LIBERATION OF PLANT FOOD

The chemical analysis of the soil gives the invoice of fertility actually present in the soil strata sampled and analyzed, but the rate of liberation is governed by many factors, some of which may be controlled by the farmer, while others are largely beyond his control. Chief among the important controllable factors which influence the liberation of plant food are limestone and decaying organic matter. Tillage also has a considerable effect in this connection.

Effect of Limestone.—Limestone corrects the acidity of the soil and thus encourages the development not only of the nitrogen-gathering bacteria which live in the nodules on the roots of clover, cowpeas, and other legumes, but also the nitrifying bacteria, which have power to transform the insoluble and unavailable organic nitrogen into soluble and available nitrate nitrogen. At the same time, the products of this decomposition have power to dissolve the minerals contained in the soil, such as potassium and magnesium, and also to dissolve the insoluble phosphate and limestone which may be applied in low-priced forms. Thus, in the conversion of sufficient organic nirogen into nitrate nitrogen for a 100-bushel crop of corn, the nitrous acid formed is alone sufficient to convert seven times as much insoluble tricalcium phosphate into soluble monocalcium phosphate as would be required to supply the phosphorus for the same crop.

Effect of Organic Matter.—Organic matter may be supplied by animal manures, consisting of the excreta of animals and usually accompanied by more or less stable litter, and by plant manures, including green-manure crops and cover crops plowed under and also crop residues such as stalks, straw, and chaff. The rate of decay of organic matter depends largely upon its age, condition, and origin, and it may be hastened by tillage. The chemical analysis shows correctly the total organic carbon, which constitutes, as a rule, but little more than half the organic matter; so that 20,000 pounds of organic carbon in the plowed soil of an acre corresponds to nearly 20 tons of organic matter. But this organic matter consists largely of the old organic residues that have accumulated during the past centuries because they were resistant to decay, and 2 tons of clover or cowpeas plowed under may have greater power to liberate plant food than the 20 tons of old, inactive organic matter. The history of the individual

farm or field must be depended upon for information concerning recent additions of active organic matter, whether in applications of farm manure, in legume crops, or in sods of old pastures.

The condition of the organic matter of the soil is indicated more or less definitely by the *ratio of carbon to nitrogen.* As an average, the fresh organic matter incorporated with soils contains about twenty times as much carbon as nitrogen, but the carbohydrates ferment and decompose much more rapidly than the nitrogenous matter; and the old resistant organic residues, such as are found in normal subsoils, commonly contain only five or six times as much carbon as nitrogen. Soils of normal physical composition, such as loam, clay loam, silt loam, and fine sandy loam, when in good productive condition, contain about twelve to fourteen times as much carbon as nitrogen in the surface soil; while in old, worn soils that are greatly in need of fresh, active, organic manures, the ratio is narrower, sometimes falling below ten of carbon to one or nitrogen. Except in newly made alluvial soils, the ratio is usually narrower in the subsurface and subsoil than in the surface stratum. Soils of cut-over or burnt-over timber lands sometimes contain so much partially decayed wood or charcoal as to destroy the value of the nitrogen-carbon ratio for the purpose indicated.

The organic matter furnishes food for bacteria, and as it decays certain decomposition products are formed, including much carbonic acid, some nitrous acid, and various organic acids, and these acting upon the soil have the power to dissolve the essential mineral plant foods, thus furnishing soluble phosphates, nitrates, and other salts of potassium, magnesium, calcium, etc., for the use of the growing crop.

Effect of Tillage.—Tillage, or cultivation, also hastens the liberation of plant food by permitting the air to enter the soil. It should be remembered, however, that tillage is wholly destructive, in that it adds nothing whatever to the soil, but always leaves it poorer, so far as plant food is concerned. Tillage should be practiced so far as is necessary to prepare a suitable seed bed for root development and also for the purpose of killing weeds, but more than this is unnecessary and unprofitable; and it is much better actually to enrich the soil by proper applications of limestone, organic matter and other fertilizing materials, and thus promote soil conditions favorable for vigorous plant growth, than to depend upon excessive cultivation to accomplish the same object at the expense of the soil.

PERMANENT SOIL IMPROVEMENT

According to the kind of soil involved, any comprehensive plan contemplating a permanent system of agriculture will need to take into account some of the following considerations.

The Application of Limestone

The Function of Limestone.—In considering the application of limestone to land it should be understood that this material functions in several different ways, and that a beneficial result may therefore be attributable to quite diverse causes: Limestone provides the plant food calcium, of which certain crops are strong feeders. It corrects acidity of the soil, thus making for some crops a much

more favorable environment as well as establishing conditions absolutely required for some of the beneficial legume bacteria. It accelerates nitrification and nitrogen fixation. It promotes sanitation of the soil by preventing the growth of certain fungus diseases, such as corn root rot. Experience indicates that it modifies directly the physical structure of some soils, frequently to their great improvement.

Thus, working in one or more of these different ways, limestone often becomes the key to the improvement of worn lands. Remarkable success has been experienced with limestone used in conjunction with sweet clover in the reclamation of abandoned hill land which had been ruined thru erosion.

Amounts to Apply.—If the soil is acid, at least 2 tons per acre of ground limestone should be applied as an initial treatment. Continue to apply limestone from time to time according to the requirement of the soil as indicated by the tests described below, or until the most favorable conditions are established for the growth of legumes, using preferably at times magnesian limestone ($CaCO_3MgCO_3$), which contains both calcium and magnesium and has slightly greater power to correct soil acidity, ton for ton, than the ordinary calcium limestone ($CaCO_3$). On strongly acid soils, or on land being prepared for alfalfa, 4 or 5 tons per acre of ground limestone may well be used for the first application.

How to Ascertain the Need for Limestone.—The need of a soil for limestone may be ascertained by applying one of the following tests for soil acidity. Along with the acidity test, a test for the presence of carbonates should be made. It should be understood that a positive test for carbonates does not guarantee the absence of acid; for it may happen, especially when the soil is near the neutral point, that positive tests for both acidity and carbonates are obtained. This condition is explained by the assumption that solid particles of calcium or magnesium carbonates form centers of alkalinity within a soil that is generally acid. Because of this fact any test made of a given soil ought to be repeated if it is to be thoroly reliable. It is also desirable to test samples from different depths. Following are the directions for making these tests:

The Litmus Paper Test for Acidity. Make a ball of fresh moist soil, break it in two, insert a piece of blue litmus paper, and press the soil firmly together again. After a few minutes examine the paper. If it has turned pink or red, soil acidity is indicated. The intensity of the color and the rapidity with which it develops indicates to some extent the amount of acidity. Needless to say the reliability of the test depends upon the quality of litmus paper used.

The Potassium Thiocyanate Test for Acidity. A more recently discovered test for soil acidity which promises to be more satisfactory than the litmus test is made with a 4-percent solution of potassium thiocyanate in alcohol—4 grams of potassium thiocyanate in 100 cubic centimeters of 95-percent alcohol (not denatured). When a small quantity of soil shaken up in a test tube with this solution gives a red color the soil is acid and limestone should be applied. If the solution remains colorless the soil is not acid. The conditions for a prompt reaction require a temperature that is comfortably warm.

The Hydrochloric Acid Test for Carbonates. Make a shallow cup of a ball of soil and pour into it a few drops of concentrated hydrochloric acid. If carbonates are present they are decomposed with the liberation of carbon dioxid, which appears as gas bubbles, producing foaming or effervescence. With much carbonate present the action is lively, but with mere traces of it the bubbles are given off slowly. If no carbonate, or very little, is indicated by the test, then it is advisable to apply limestone.

The Nitrogen Problem

Nitrogen presents the greatest practical soil problem in American agriculture. Four important reasons for this are: its increasing deficiency in most soils; its cost when purchased on the open market; its removal in large amounts by crops; and its loss from soils thru leaching. Nitrogen costs from four to

five times as much per pound as phosphorus. A 100-bushel crop of corn requires 150 pounds of nitrogen for its growth, but only 23 pounds of phosphorus. The loss of nitrogen from soils may vary from a few pounds to over one hundred pounds per acre, depending upon the treatment of the soil, the distribution of rainfall, and the protection afforded by growing crops.

An inexhaustible supply of nitrogen is present in the air. Above each acre of the earth's surface there are about sixty-nine million pounds of atmospheric nitrogen. The nitrogen above one square mile weighs twenty million tons, an amount sufficient to supply the entire world for four or five decades. This large supply of nitrogen in the air is the one to which the world must eventually turn.

There are two methods of collecting the inert nitrogen gas of the air and combining it into compounds that will furnish products for agricultural uses. *These are the chemical and the biological fixation of the atmospheric nitrogen.* Farmers have at their command one of these methods. By growing inoculated legumes, nitrogen may be obtained from the air, and by plowing under more than the roots of those legumes, nitrogen may be added to the soil.

Inasmuch as legumes are worth growing for feed and seed as well as for nitrate production, a considerable portion of the nitrogen thus gained may be considered a by-product. Because of that fact, it is questionable whether the chemical fixation of nitrogen, the possibilities of which now represent numerous compounds, will ever be able to replace the simple method of obtaining atmospheric nitrogen by growing inoculated legumes.

For easy figuring it may well be kept in mind that the following amounts of nitrogen are required for the produce named:

1 bushel of oats (grain and straw) requires 1 pound of nitrogen.
1 bushel of corn (grain and stalks) requires 1½ pounds of nitrogen.
1 bushel of wheat (grain and straw) requires 2 pounds of nitrogen.
1 ton of timothy requires 24 pounds of nitrogen.
1 ton of clover contains 40 pounds of nitrogen.
1 ton of cowpeas contains 43 pounds of nitrogen.
1 ton of alfalfa contains 50 pounds of nitrogen.
1 ton of average manure contains 10 pounds of nitrogen.
1 ton of young sweet clover, at about the stage of growth when it is plowed under as green manure, contains, on water-free basis, 80 pounds of nitrogen.

The roots of clover contain about half as much nitrogen as the tops, and the roots of cowpeas contain about one-tenth as much as the tops. Soils of moderate productive power will furnish as much nitrogen to clover (and two or three times as much to cowpeas) as will be left in the roots and stubble. In grain crops, such as wheat, corn, and oats, about two-thirds of the nitrogen is contained in the grain and one-third in the straw or stalks.

The Phosphorus Problem

The element phosphorus is an indispensable constituent of every living cell. It is intimately connected with the life processes of both plants and animals, the nuclear material of the cells being especially rich in this element.

The phosphorus content of a soil varies according to its origin and the kind of farming practiced. Even virgin soils are found that are deficient in phosphorus.

On all lands deficient in phosphorus (except on those susceptible to serious erosion by surface washing or gullying) that element should be applied in considerably larger amounts than are required to meet the actual needs of the crops desired to be produced. The abundant information thus far secured shows positively that fine-ground natural rock phosphate can be used successfully and very profitably, and clearly indicates that this material will be the most economical form of phosphorus to use in all ordinary systems of permanent, profitable soil improvement. The first application may well be one ton per acre, and subsequently about one-half ton per acre every four or five years should be applied, at least until the phosphorus content of the plowed soil reaches 2,000 pounds per acre, which may require a total application of from 3 to 5 or 6 tons per acre of raw phosphate containing 12½ percent of the element phosphorus.

Steamed bone meal and even acid phosphate may be used in emergencies, but it should always be kept in mind that a pound of phosphorus delivered in Illinois in the form of raw phosphate (direct from the mine in carload lots), is much cheaper than the same amount in steamed bone meal or in acid phosphate, both of which cost too much per ton to permit their common purchase by farmers in carload lots, which is not the case with raw phosphate. Landowners should bear in mind the fact that phosphorus additions to the soil in amounts above the immediate crop requirements represent a permanent investment, since this element is not readily lost in the drainage water as in the case of nitrogen. It is removed from the farm thru the sale of crops, milk, and animals.

Phosphate may be applied at any time during a rotation, but it is applied to the best advantage either preceding a crop of clover, which plant seems to possess an unusual power for assimilating raw phosphate, or else at a time when it can be plowed under with some form of organic matter such as animal manure or green manure, the decay of which serves to liberate the phosphorus from its insoluble condition in the rock. It is important that the fine-ground rock phosphate be intimately mixed with the organic material as it is plowed under.

The Potassium Problem

Normal soils, in which clay and silt form a considerable part of the constituency, are well stocked with potassium, altho it exists largely in insoluble form. Such soils as sands and peats, however, are likely to be low in this element. On such soils this deficiency may be supplied by the application of some potassium salt, such as potassium sulfate, potassium chlorid, kainit, or other potassium compound, and in many instances this is done at great profit.

From all the facts at hand it seems, so far as our great areas of normal soils are concerned, that the potassium problem is not one of addition but of liberation. The Rothamsted records, which represent the oldest soil experiment fields in the world, show that for many years other soluble salts have practically the same power as potassium to increase crop yield in the absence of sufficient decaying organic matter. Whether this action relates to supplying or liberating potassium for its own sake, or to the power of the soluble salt to increase the availability of phosphorus or other elements, is not known, but where much

potassium is removed, as in the entire crops at Rothamsted, with no return of organic residues, probably the soluble salt functions in both ways.

Further evidence on this matter is furnished by the Illinois experiment field at Fairfield, where potassium sulfate has been compared with kainit both with and without the addition of organic matter in the form of stable manure. Both sulfate and kainit produced a substantial increase in the yield of corn. but the cheaper salt, kainit, was just as effective as the potassium sulfate, and returned some financial profit. Manure alone gave an increase similar to that produced by the potassium salts, but the salts added to the manure gave very little increase over that produced by the manure alone. This is explained in part perhaps because the potassium removed in the crops is mostly returned in the manure if properly cared for, and perhaps in larger part because the decaying organic matter helps to liberate and hold in solution other plant-food elements, especially phosphorus.

In laboratory experiments at the Illinois Experiment Station, it has been shown that potassium salts and most other soluble salts increase the solubility of the phosphorus in soil and in rock phosphate; also that the addition of glucose with rock phosphate in pot-culture experiments increases the availability of the phosphorus, as measured by plant growth, altho the glucose consists only of carbon, hydrogen, and oxygen, and thus contains no plant food of value.

In considering the conservation of potassium on the farm it should be remembered that in average live-stock farming the animals destroy two-thirds of the organic matter and retain one-fourth of the nitrogen and phosphorus from the food they consume, but that they retain less than one-tenth of the potassium; so that the actual loss of potassium in the products sold from the farm, either in grain farming or in live-stock farming, is negligible on land containing 25,000 pounds or more of potassium in the surface 6⅔ inches.

The Calcium and Magnesium Problem

When measured by the actual crop requirements for plant food, magnesium and calcium are more limited in some Illinois soils than potassium. But with these elements we must also consider the loss by leaching.

Doctor Edward Bartow and associates, of the Illinois State Water Survey, have shown that as an average of 90 analyses of Illinois well-waters drawn chiefly from glacial sands, gravels, or till, 3 million pounds of water (about the average annual drainage per acre for Illinois) contained 11 pounds of potassium, 130 of magnesium, and 330 of calcium. These figures are very significant, and it may be stated that if the plowed soil is well supplied with the carbonates of magnesium and calcium, then a very considerable proportion of these amounts will be leached from that stratum. Thus the loss of calcium from the plowed soil of an acre at Rothamsted, England, where the soil contains plenty of limestone, has averaged more than 300 pounds a year as determined by analyzing the soil in 1865 and again in 1905. And practically the same amount of calcium was found by analyzing the Rothamsted drainage waters.

Common limestone, which is calcium carbonate ($CaCO_3$), contains, when pure, 40 percent of calcium, so that 800 pounds of limestone is equivalent to 320 pounds of calcium. Where 10 tons per acre of ground limestone was applied at Edgewood, Illinois, the average annual loss during the next ten

years amounted to 790 pounds per acre. The definite data from careful investigations seems to be ample to justify the conclusion that where limestone is needed at least 2 tons per acre should be applied every four or five years.

It is of interest to note that thirty crops of clover of 4 tons each would require 3,510 pounds of calcium, while the most common prairie land of southern Illinois contains only 3,420 pounds of total calcium in the plowed soil of an acre. Thus limestone has a positive value on some soils for the plant food which it supplies, in addition to its value in correcting soil acidity and in improving the physical condition of the soil. Ordinary limestone (abundant in the southern and western parts of the state) contains nearly 800 pounds of calcium per ton; while a good grade of dolomitic limestone (the more common limestone of northern Illinois) contains about 400 pounds of calcium and 300 pounds of magnesium per ton. Both of these elements are furnished in readily available form in ground dolomitic limestone.

The Sulfur Question

In considering the relation of sulfur in a permanent system of soil fertility it is important to understand something of the cycle of transformations that this element undergoes in nature. Briefly stated this is as follows:

Sulfur exists in the soil in both organic and inorganic forms, the former being gradually converted to the latter form thru bacterial action. In this inorganic form sulfur is taken up by plants which in their physiological processes change it once more into an organic form as a constituent of protein. When these plant proteins are consumed by animals, the sulfur becomes a part of the animal protein. When these plant and animal proteins are decomposed, either thru bacterial action, or thru combustion, the sulfur passes into the atmosphere or into the soil solution in the form of sulfur dioxid gas. This gas unites with oxygen and water to form sulfuric acid, which is readily washed back into the soil by the rain, thus completing the cycle, from soil—to plants and animals —to air—to soil.

In this way sulfur becomes largely a self-renewing element of the soil, altho there is a considerable loss from the soil by leaching. Observations taken at the Illinois Agricultural Experiment Station show that 40 pounds of sulfur per acre are brought into the soil thru the annual rainfall. With a fair stock of surfur, such as exists in our common types of soil, and an annual return, which of itself would more than suffice for the needs of maximum crops, the maintenance of an adequate sulfur supply presents little reason at present for serious concern. There are regions, however, where the natural stock of sulfur in the soil is not nearly so high and where the amount returned thru rainfall is small. Under such circumstances sulfur soon becomes a limiting element of crop production, and it will be necessary sooner or later to introduce this substance from some outside source. Investigation is now under way to determine to what extent this situation may apply to conditions in Illinois.

Physical Improvement of Soils

In the management of most soil types, one very important thing, aside from proper fertilization, tillage, and drainage, is to keep the soil in good physical condition, or good tilth. The constituent most important for this purpose is

organic matter. Organic matter in producing good tilth helps to control washing of soil on rolling land, raises the temperature of drained soil, increases the moisture-holding capacity of the soil, retards capillary rise and consequently loss of moisture by surface evaporation, and helps to overcome the tendency of some soils to run together badly.

The physical effect of organic matter is to produce a granulation or mellowness, by cementing the fine soil particles into crumbs or grains about as large as grains of sand, which produces a condition very favorable for tillage, percolation of rainfall, and the development of plant roots.

Organic matter is being destroyed during a large part of the year and the nitrates produced in its decomposition are used for plant growth. Altho this decomposition is necessary, it nevertheless reduces the amount of organic matter, and provision must therefore be made for maintaining the supply. The practical way to do this is to turn under the farm manure, straw, corn stalks, weeds, and all or part of the legumes produced on the farm. The amount of legumes needed depends upon the character of the soil. There are farms, especially grain farms, in nearly every community where all legumes could be turned under for several years to good advantage.

Manure should be spread upon the land as soon as possible after it is produced, for if it is allowed to lie in the barnyard several months as is so often the case, from one-third to two-thirds of the organic matter will be lost.

Straw and corn stalks should be turned under, and not burned. Probably no form of organic matter acts more beneficially in producing good tilth than corn stalks. It is true, they decay rather slowly, but it is also true that their durability in the soil is exactly what is needed in the production of good tilth. Furthermore, the nitrogen in a ton of corn stalks is one and one-half times that of a ton of manure, and a ton of dry corn stalks incorporated in the soil will ultimately furnish as much humus as four tons of average farm manure. When burned, however, both the humus-making material and the nitrogen are lost to the soil.

It is a common practice in the corn belt to pasture the corn stalks during the winter and often rather late in the spring after the frost is out of the ground. This tramping by stock sometimes puts the soil in bad condition for working. It becomes partially puddled and will be cloddy as a result. If tramped too late in the spring, the natural agencies of freezing and thawing and wetting and drying, with the aid of ordinary tillage, fail to produce good tilth before the crop is planted. Whether the crop is corn or oats, it necessarily suffers, and if the season is dry, much damage may be done. If the field is put in corn, a poor stand is likely to result, and if put in oats, the soil is so compact as to be unfavorable for their growth. Sometimes the soil is worked when too wet. This also produces a partial puddling which is unfavorable to physical, chemical, and biological processes. The bad effect will be greater if cropping has reduced the organic matter below the amount necessary to maintain good tilth.

Systems of Crop Rotations

In a program of permanent soil improvement one should adopt at the outset a good rotation of crops, including a liberal use of legumes, in order to increase the organic matter of the soil either by plowing under the legume crops and

other crop residues (straw and corn stalks), or by using for feed and bedding practically all the crops raised and returning the manure to the land with the least possible loss. No one can say in advance for every particular case what will prove to be the best rotation of crops, because of variation in farms and farmers and in prices for produce.

Following are a few suggested rotations, applicable to the corn belt, which may serve as models or outlines to be modified according to special circumstances.

Six-Year Rotations

First year —Corn
Second year —Corn
Third year —Wheat or oats (with clover or clover and grass)
Fourth year —Clover, or clover and grass
Fifth year —Wheat (with clover) or grass and clover
Sixth year —Clover, or clover and grass

Of course there should be as many fields as there are years in the rotation. In grain farming, with small grain grown the third and fifth years, most of the unsalable products should be returned to the soil, and the clover may be clipped and left on the land or returned after threshing out the seed (only the clover seed being sold the fourth and sixth years); or, in live-stock farming, the field may be used three years for timothy and clover pasture and meadow if desired. The system may be reduced to a five-year rotation by cutting out either the second or the sixth year, and to a four-year system by omitting the fifth and sixth years, as indicated below.

Five-Year Rotations

First year —Corn
Second year —Wheat or oats (with clover, or clover and grass)
Third year —Clover, or clover and grass
Fourth year —Wheat (with clover), or clover and grass
Fifth year —Clover, or clover and grass

First year —Corn
Second year —Corn
Third year —Wheat or oats (with clover, or clover and grass)
Fourth year —Clover, or clover and grass
Fifth year —Wheat (with clover)

First year —Corn
Second year —Cowpeas or soybeans
Third year —Wheat (with clover)
Fourth year —Clover
Fifth year —Wheat (with clover)

The last rotation mentioned above allows legumes to be seeded four times. Alfalfa may be grown on a sixth field for five or six years in the combination rotation, alternating between two fields every five years, or rotating over all the fields if moved every six years.

Four-Year Rotations

First year —Wheat (with clover)	*First year* —Corn
Second year —Corn	*Second year* —Corn
Third year —Oats (with clover)	*Third year* —Wheat or oats (with clover)
Fourth year —Clover	*Fourth year* —Clover
First year —Corn	*First year* —Wheat (with clover)
Second year —Wheat or oats (with colver)	*Second year* —Clover
Third year —Clover	*Third year* —Corn
Fourth year —Wheat (with clover)	*Fourth year* —Oats (with clover)

First year —Corn
Second year —Cowpeas or soybeans
Third year —Wheat (with clover)
Fourth year —Clover

Alfalfa may be grown on a fifth field for four or eight years, which is to be alternated with one of the four; or the alfalfa may be moved every five years. and thus rotated over all five fields every twenty-five years.

Three-Year Rotations

First year —Corn	*First year* —Wheat (with clover)
Second year —Oats or wheat (with clover)	*Second year* —Corn
Third year —Clover	*Third year* —Cowpeas or soybeans

By allowing the clover, in the last rotation mentioned, to grow in the spring before preparing the land for corn, we have provided a system in which legumes grow on every acre every year. This is likewise true of the following suggested two-year system:

Two-Year Rotation

First year —Oats or wheat (with sweet clover)
Second year —Corn

Altho in this two-year rotation either oats or wheat is suggested, as a matter of fact, by dividing the land devoted to small grain, both of these crops can be grown simultaneously, thus providing a three-crop system in a two-year cycle.

It should be understood that in all of the above suggested cropping systems it may be desirable in some cases to substitute rye for the wheat or oats. In all of these proposed rotations the word *clover* is used in a general sense to designate either red clover, alsike clover, or sweet clover. The value of sweet clover especially as a green manure for building up depleted soils, as well as a pasture and hay crop, is becoming thoroly established, and its importance in a crop-rotation program may well be emphasized.

SUPPLEMENT: EXPERIMENT FIELD DATA

(Results from Experiment Fields Representing the More Important Types of Soil Occurring in McHenry County)

In the earlier reports of this series it was the practice to incorporate in the body of the report the results of certain experiment fields, for the purpose of illustrating the possibilities of improving the soil of various types. The information carried by such data must, naturally, be considered more or less tentative. As the fields grow older new facts develop, which in some instances may call for the modification of former recommendations. It has therefore seemed desirable to separate this experiment field data from the more permanent information of the soil survey, and embody the same in the form of a supplement to the soil report proper, thus providing a convenient arrangement for possible future revisions as further data accumulate.

The University of Illinois has conducted altogether about fifty soil experiment fields in different sections of the state and on various types of soil. Altho some of these fields have been discontinued, the large majority are still in operation. It is the present purpose to report the summarized results from certain of these fields which are representative of the types of soil described in the accompanying soil report.

A few general explanations at this point, which apply to all the fields, will relieve the necessity of numerous repetitions in the following pages.

These fields vary in size from less than two acres up to 40 acres or more. They are laid off into series of plots and each series is occupied by one kind of crop. Usually there are several series so that a crop rotation can be carried on with every crop represented every year.

Farming Systems

On many of the fields the treatment provides for two distinct systems of farming, live-stock and grain farming. *In the live-stock system,* stable manure is used to furnish organic matter and nitrogen. The amount applied to a plot is based upon the amount that can be produced from crops raised on that plot.

In the grain system no animal manure is used. The organic matter and nitrogen are supplied in the form of plant manures, including plant residues produced, such as stalks and straw, along with leguminous catch crops plowed under.

Rotations

Crops which are of interest in the respective localities are grown in definite rotations, and on most of the fields provision is made so that every crop in the rotation is represented every year. The most common rotation used is wheat, corn, oats, and clover; and often these crops are accompanied by alfalfa growing on a fifth series. In the grain system a legume catch crop, usually sweet clover, is included, which is seeded on the young wheat in the spring and plowed under in the fall or in the following spring in preparation for corn. In the event of clover failure, soybeans are substituted.

Soil Treatment

The treatment applied to the plots has, for the most part, been standardized according to a definite system, altho deviations from this system occur now and then, particularly in the older fields.

Following is a brief explanation of this standard system of treatment.

Animal Manures.—Animal manures, consisting of excreta from animals, with stable litter, are spread upon the respective plots in amounts proportionate to previous crop yields, the applications being made in the preparation for corn.

Plant Manures.—All crop residues produced on the land, such as stalks, straw, and chaff, are returned to the soil, and in addition a green-manure crop of sweet clover is seeded in small grains to be plowed under in preparation for corn. (On plots where limestone is lacking the sweet clover seldom survives.) This practice is designated as the *residues system.*

Mineral Manures.—The yearly acre-rates of application are: for limestone, 1,000 pounds; for raw rock phosphate, 500 pounds; and for potassium, the equivalent of 200 pounds of kainit. The initial application of limestone is usually 4 tons per acre.

Explanation of Symbols Used

0 = Untreated land or check plots
M = Manure (animal)
R = Residues (from crops, and includes legumes used as green manure)
L = Limestone
P = Phosphorus
K = Potassium (usually in the form of kainit)
N = Nitrogen (usually in the form contained in dried blood)
( ) = Parentheses enclosing figures signify tons of hay, as distinguished from bushels of seed

In discussions of this sort of data, financial profits or losses based upon assigned market values are frequently considered. However, in view of the erratic fluctuations in market values—especially in the past few years—it seems futile to attempt to set any prices for this purpose that are at all satisfactory. The yields are therefore presented with the thought that with these figures at hand the financial returns from a given practice can readily be computed upon the basis of any set of market values that the reader may choose to apply.

BROWN SILT LOAM

Several experiment fields have been conducted on brown silt loam soil at various locations in Illinois. Those located at the University have been in operation the longest and they serve well to illustrate the principles involved in the maintenance and improvement of this type of soil.

The Morrow Plots

It happens that the oldest soil experiment field in the United States is located on typical brown silt loam of the early Wisconsin glaciation, on the campus of the University of Illinois. This field was started in 1879 by George E. Morrow, who for many years was Professor of Agriculture, and these plots are known as the Morrow plots.

TABLE 1.—URBANA FIELD, MORROW PLOTS: BROWN SILT LOAM; PRAIRIE; EARLY WISCONSIN GLACIATION

Crop Yields in Soil Experiments—Bushels or (tons) per acre

Years	Soil treatment applied	Corn every year	Two-year rotation		Three-year rotation		
		Corn	Corn	Oats	Corn	Oats	Clover
1879–87	None.......	....	....	....	....	....	....
1888	None.......	54.3	49.5	....	....	48.6	....
1889	None.......	43.2	....	37.4	....	....	(4.04)
1890	None.......	48.7	54.3	....	....	....	(1.51)
1891	None.......	28.6	33.2	....	....	....	(1.46)
1892	None.......	33.1	....	37.2	70.2	....	....
1893	None.......	21.7	29.6	....	34.1	....	....
1894	None.......	34.8	....	57.2	....	65.1	....
1895	None.......	42.2	41.6	....	....	22.2	....
1896	None.......	62.3	....	34.5	....	....	....
1897	None.......	40.1	47.0	....	....	....	....
1898	None.......	18.1	....	....	....	....	....
1899	None.......	50.1	44.4	....	53.5	....	....
1900	None.......	48.0	....	41.5	....	....	....
1901	None.......	23.7	33.7	....	34.3	....	....
1902	None.......	60.2	....	56.3	....	54.6	....
1903	None.......	26.0	35.9	....	....	....	(1.11)
1904	None.......	21.5	....	17.5	55.3	....	....
1904	MLP.......	17.1	....	25.3	72.7	....	....
1905	None.......	24.8	50.0	....	....	42.3	....
1905	MLP.......	31.4	44.9	....	....	50.6	....
1906	None.......	27.1	....	34.7	....	....	(1.42)[1]
1906	MLP.......	35.8	....	52.4	....	....	(1.74)[1]
1907	None.......	29.0	47.8	....	80.5	....	....
1907	MLP.......	48.7	87.6	....	93.6	....	....
1908	None.......	13.4	....	32.9	....	40.0	....
1908	MLP.......	28.0	....	45.0	....	44.4	....
1909	None.......	26.6	33.0	....	....	....	(.65)[2]
1909	MLP.......	31.6	64.8	....	....	....	(1.73)[3]
1910	None.......	35.9	....	33.8	58.6	....	....
1910	MLP.......	54.6	....	59.4	83.3	....	....
1911	None.......	21.9	28.6	....	....	20.6	....
1911	MLP.......	31.5	46.3	....	....	38.0	....
1912	None.......	43.2	....	55.0	....	....	16.3[1]
1912	MLP.......	64.2	....	81.0	....	....	20.0[1]
1913	None.......	19.4	29.2	....	33.8	....	....
1913	MLP.......	32.0	25.0	....	47.8	....	....
1914	None.......	31.6	....	33.6	....	39.6	....
1914	MLP.......	39.4	....	58.2	....	60.4	....
1915	None.......	40.0	49.0	....	....	....	24.2[1]
1915	MLP.......	66.0	81.2	....	....	....	27.1[1]
1916	None.......	11.2	....	37.5	27.8	....	....
1916	MLP.......	10.8	....	64.7	40.6	....	....
1917	None.......	40.0	48.4	....	....	68.4	....
1917	MLP.......	78.0	81.4	....	....	86.9	....
1918	None.......	13.6	....	27.2	....	....	(2.58)
1918	MLP.......	32.6	....	59.3	....	....	(4.04)
1919	None.......	24.0	30.8	....	52.2	....	....
1919	MLP.......	43.4	66.2	....	70.8	....	....
1920	None.......	28.2	....	37.2	....	52.2	....
1920	MLP.......	54.4	....	51.6	....	69.7	....

[1]Soybeans.
[2]In addition to the hay, .64 bushel of seed was harvested.
[3]In addition to the hay, 1.17 bushels of seed were harvested.

TABLE 2.—URBANA FIELD, MORROW PLOTS: GENERAL SUMMARY

Bushels or (tons) per acre

Years	Soil treatment applied	Corn every year	Two-year rotation		Three-year rotation		
			Corn	Oats	Corn	Oats	Clover
		16 crops	*9 crops*	*6 crops*	*4 crops*	*4 crops*	*4 crops*
1888 to 1903	None.......	39.7	41.0	44.0	48.0	47.6	(2.03)
		17 crops	*8 crops*	*9 crops*	*6 crops*	*6 crops*	*3 crops*
1904 to 1920	None.......	26.6	39.6	34.4	51.4	43.9	(1.55)[1]
	MLP.......	41.1	62.2	55.2	68.1	58.3	(2.50)[1]

[1]One crop of soybean hay.

The Morrow series now consists of three plots divided into halves and the halves are subdivided into quarters. On one plot corn is grown continuously; on the second corn and oats are grown in rotation; and on the third, corn, oats, and clover are rotated. The north half of each plot has had no fertilizing material applied from the beginning of the experiments, while the south half has been treated since 1904, receiving standard applications of farm manure with cover crops grown in the one-crop and two-crop systems. Phosphorus has been applied in two different forms: rock phosphate to the southwest quarter at the rate of 600 pounds, and steamed bone meal to the southeast quarter at the rate of 200 pounds per acre per year up to 1919, when the rock phosphate was increased sufficiently to bring up the total amount applied to four times the quantity of bone meal applied. At the same time the rate of subsequent application of both forms of phosphorus was reduced to one-fourth the quantity, or to 200 pounds of rock phosphate and 50 pounds of bone meal per acre per year. In 1904 ground limestone was applied at the rate of 1,700 pounds per acre to the south half of each plot, and in 1918 a further application was made at the rate of 5 tons per acre with the intention of standardizing the application to the rate of 1,000 pounds of limestone per acre per year.

FIG. 1.—CORN ON THE MORROW PLOTS IN 1910

Table 1 gives the yearly records of the crop yields, and Table 2 presents the same in summarized form.

Summarizing the data from these Morrow plots into two periods with the second period beginning in 1904 when the treatment began on the half-plots, some interesting comparisons may be made. In the first place we find in the continuous corn plot a marked decrease in the second period in the average yield of corn, amounting to one-third of the crop. In the two-year rotation there is a decrease in both corn and oats production, while the averages for the three-year system show an increase in corn yield and decreases in oats and clover. Unfortunately the numbers of crops included in these last averages are too small to warrant positive conclusions.

The increase brought about by soil treatment stands out in all cases, showing the possibility not only of restoring but also of greatly improving the productive power of this land that has been so abused by continuous cropping without fertilization.

The Davenport Plots

Another set of plots on the University campus at Urbana, forming a more extensive series than the Morrow plots, but of more recent origin, are the Davenport plots. Here each crop in the rotation is represented every year. These plots were laid out in 1895, but special soil treatment was not begun until 1901. They now comprize five series of ten plots each, and each series constitutes a "field" in a crop rotation system.

From 1901 to 1911 three of the series were in a three-year rotation system of corn, oats, and clover, while the remaining two series rotated in corn and oats. In 1911 these two systems were combined into a five-series field, with a crop rotation of wheat, corn, oats, and clover, with alfalfa on a fifth field. The alfalfa occupies one series during a rotation of the other four crops, shifting to another series in the fifth year, thus completing the cycle of all series in twenty-five years.

The soil treatment applied to these plots has been as follows:

Legume cover crops were seeded in the corn at the last cultivation on Plots 2, 4, 6, and 8, from 1902 to 1907, but the growth was small and the effect, if any, was to decrease the returns from the regular crops. Crop residues (**R**) have been returned to these same plots since 1907. These consist of stalks and straw, and all legumes except alfalfa hay and the seed of clover and soybeans. Beginning in 1918 a modification of the practice was made in that one cutting of the red clover crop is harvested as hay. In conjunction with these residues a catch crop of sweet clover grown with the wheat is plowed under.

Manure (**M**) was applied preceding corn, at the rate of 2 tons per acre per year in 1905, 1906, and 1907; subsequently as many tons have been applied as there have been tons of air-dry produce harvested from the respective plots.

Lime (**L**) was applied on Plots 4 to 10 at the rate per acre of 250 pounds of air-slaked lime in 1902, and 600 pounds of limestone in 1903. No further application was made until 1911, when the system of cropping was changed. Since that time applications of limestone have been made at the rate of one-half ton per acre per year.

Phosphorus (**P**) was applied on Plots 6 to 9 at the rate of 25 pounds per acre per annum in 200 pounds of steamed bone meal; but beginning with 1908 rock phosphate at the rate of 600 pounds per acre per annum was substi-

TABLE 3.—URBANA FIELD, DAVENPORT PLOTS: BROWN SILT LOAM, PRAIRIE; EARLY WISCONSIN GLACIATION

Ten-Year Average Annual Yields—Bushels or (tons) per acre
1911-1920

Serial plot No.	Soil treatment applied	Corn	Oats	Wheat	Clover 5 crops	Soybeans 5 crops	Alfalfa
1	0	55.6	50.5	26.0	(2.42)	(1.47)	(2.43)
2	R	57.1	52.3	28.7	1.47[1]	19.8	(2.46)
3	M	66.3	61.9	28.2	(2.56)	(1.62)	(2.52)
4	RL	64.8	55.6	31.4	1.61[1]	20.3	(2.72)
5	ML	69.6	64.1	32.8	(2.90)	(1.67)	(3.03)
6	RLP	71.5	69.8	43.0	2.29[1]	23.5	(3.69)
7	MLP	73.0	68.6	40.0	(3.52)	(1.97)	(3.76)
8	RLPK	70.9	72.5	40.7	1.79[1]	25.5	(3.77)
9	MLPK	70.2	72.0	39.2	(3.40)	(2.20)	(3.73)
10	Mx5LPx5	65.9	71.4	40.6	(3.31)	(2.22)	(3.77)

[1]In addition to the clover seed, a crop of hay was harvested one year on Plots 2, 4, 6, and 8, yielding 2.38, 2.20, 2.54, and 2.39 tons, respectively.

tuted for the bone meal on one-half of each of these plots. These applications continued until 1918 when adjustments were begun, first to make the rate of application of rock phosphate four times that of the bone meal, and finally to reduce the amounts of these materials to 200 pounds of rock phosphate and 50 pounds of bone meal per acre per annum. The usual practice has been to apply and plow under at one time all phosphorus and potassium required for the rotation.

Potassium (K = kalium) has been applied on Plots 8 and 9 in connection with the bone meal and rock phosphate, at the yearly rate of 42 pounds per acre, and mainly as potassium sulfate.

On Plot 10 about five times as much manure and phosphorus are applied as on the other plots, but this "extra heavy" treatment was not begun until 1906, only the usual lime, phosphorus, and potassium having been applied in previous years. The purpose in making these heavy applications is to try to determine the climatic possibilities in crop yields by removing the limitations of inadequate fertility.

It will be observed that the applications described above provide for the two rather distinct systems of farming already described. *The grain system,* in which animal manure is not produced and where the organic matter is provided by the direct return to the soil of all crop residues, is exemplified in Plots 2, 4, 6, and 8; and the *live-stock system,* in which farm manure is utilized for soil enrichment, is represented in Plots 3, 5, 7, and 9.

Table 3 shows a summary of the results obtained on the Davenport plots beginning with the year 1911, when the present cropping system was introduced.

When used in conjunction with phosphorus the crop residues and the manure appear about equally effective; but where phosphorus is not applied, the manure has been decidedly more effective, under the conditions of the experiment. It should be observed, however, in this connection, that the plowing under of clover is a very essential feature of the residues system, and that, as a matter of fact, there were five clover failures, when soybeans were substituted, during the ten years. Perhaps with a more reliable biennial legume than red clover, the results would have been more favorable for this system.

Manure
Yield: 1.43 tons per acre

Manure, limestone, phosphorus
Yield: 2.90 tons per acre

Fig. 2.—Clover on the Davenport Plots in 1913

By comparing Plots 2 and 3 with Plots 4 and 5, it is found that limestone has had a beneficial effect on all crops. What the financial profit amounts to depends obviously upon the market value of the crops and the cost of the limestone.

Comparing Plots 4 and 5 with Plots 6 and 7, respectively, there is found in all cases an increase in crop yield as a result of adding phosphorus. The effect on wheat is especially pronounced. Where limestone and phosphorus are applied in addition to the crop residues, an increase of 17 bushels of wheat, over the yield of the untreated land, has been obtained as a ten-year average.

The effect of adding potassium to the treatment is of much interest. Plots 8 and 9 are the same as Plots 6 and 7, respectively, except that potassium has been applied to the former. On the whole, no significant benefit is shown from the addition of potassium.

No benefit appears as the result of the extra-heavy applications of manure and phosphorus on Plot 10. In fact the corn yields are noticeably less here than on the plots receiving the normal applications of these materials.

The University South Farm

On the University South Farm, at Urbana, several series of plots devoted primarily to variety testing and other crop-production experiments are so laid out as to show the effects of certain soil treatments that have been applied.

Several different systems of crop rotation are employed and the crops are so handled as to exemplify the two general systems of farming, grain and live-stock.

The summarized results presented in Table 4 represent three different systems of cropping. The first, designated as the Southwest rotation, is to be regarded as a good rotation for general practice, on this type of soil, under Illinois conditions. This is a four-field rotation of wheat, corn, oats, and clover. The second, or North-Central rotation, consisting of corn, corn, oats, and clover, represents a system very commonly practiced; and the third or South-Central rotation, consisting of corn, corn, corn, and soybeans, must be considered as a poor rotation from the standpoint of maintaining the productiveness of the land.

TABLE 4.—URBANA FIELD, SOUTH FARM: BROWN SILT LOAM, PRAIRIE; EARLY WISCONSIN GLACIATION

Average Annual Yields—Bushels or (tons) per acre

Southwest Rotation: Series 100, 200, 400[1]: Wheat, Corn, Oats, Clover[2]

Soil treatment applied[6]	Corn 9 crops	Oats[3] 9 crops	Wheat[3] 8 crops	Clover[4] 3 crops	Soybeans 7 crops
RP	62.3	51.9	41.0	1.05	17.3[5]
R	51.9	46.5	26.9	1.38	16.2[5]
M	59.7	50.2	29.1	(2.28)	(1.25)
MP	64.3	55.4	43.1	(2.86)	(1.51)
RLP	60.5	57.2	41.8	.64	16.4[5]
R	49.7	49.6	25.8	.83	14.7[5]
M	55.5	54.1	27.8	(1.71)	(1.28)
MLP	64.1	59.6	43.9	(1.77)	(1.58)

North-Central Rotation: Series 500, 600, 700[1]: Corn, Corn, Oats, Clover[2]

Soil treatment applied[6]	Corn 1st year 9 crops	Corn 2d year 9 crops	Oats 9 crops	Clover 5 crops	Soybeans 4 crops
RP	56.7	51.1	56.1	.54	16.9
R	51.7	45.2	52.0	.50	16.0
M	54.9	46.7	52.1	(2.29)	(1.60)
MP	56.5	53.4	56.9	(2.73)	(1.74)

South-Central Rotation: Series 500, 600, 700[1]: Corn, Corn, Corn, Soybeans

Soil treatment applied[6]	Corn 1st year 9 crops	Corn 2d year 9 crops	Corn 3d year 9 crops		Soybeans 9 crops
RP	51.9	44.0	41.3		20.0
R	45.5	39.9	35.2		19.2
M	50.1	42.1	33.5		(1.59)
MP	54.5	46.7	42.0		(1.66)

[1]Results from Series 300 and 800 are omitted on account of variation in soil type.
[2]Soybeans when clover fails.
[3]Only seven crops with limestone.
[4]Only one crop with limestone.
[5]Average of five crops.
[6]All phosphorus plots received ½ ton per acre of limestone in 1903.

TABLE 5.—COMPARING PRODUCTION OF CORN IN THREE DIFFERENT ROTATION SYSTEMS
ACRE YIELDS FROM PLOTS ON THE UNIVERSITY SOUTH FARM
Twelve-Year Average (1908-1919)—Bushels per acre

Rotation	Wheat-corn-oats-legume[1]	Corn-corn-oats-legume[2]		Corn-corn-corn-legume[3]		
Treatment	Corn	1st Corn	2d Corn	1st Corn	2d Corn	3d Corn
Organic manures............	55.8	53.3	46.0	47.8	41.0	34.3
Organic manures, phosphorus.	63.2	56.6	52.3	53.2	45.3	41.6

[1]Clover 3 crops, and soybeans 7 crops.
[2]Clover 5 crops, and soybeans 5 crops.
[3]Soybeans 9 crops.

On the whole, the "residues" have not returned yields quite so high as those produced by the manure treatment; but, as remarked above in the discussion of the Davenport plots, the residues system has probably been at a disadvantage thru frequent clover failures. On the North-Central rotation, where conditions seem to have been more favorable for clover, there is very little difference between the effect of manure and of residues.

Residues plowed under
Yield: 35.2 bushels per acre

Residues and rock phosphate
Yield: 50.1 bushels per acre

FIG. 3.—WHEAT ON THE UNIVERSITY SOUTH FARM IN 1911

In the rotation system in which limestone is being applied, no benefit of consequence to any of the crops except oats appears from the use of this material. The test, however, has hardly been of sufficient duration to warrant final conclusions; and furthermore, the comparison may be somewhat impaired by a possible residual effect of the small application of limestone made in 1903 to all the phosphorus plots.

The results obtained from the use of phosphorus are important because this element has been applied to these plots solely in the form of raw rock phosphate. The figures in almost every case show an increase in yield where the phosphorus has been applied, and in most cases this increase is very pronounced. The wheat is especially responsive to phosphorus.

The records furnish some interesting comparisons of corn yields produced under different systems of cropping. Table 5 gives a general summary of the corn yields only, in which the results from the residues and manure treatments are averaged together as "organic manures." The highest annual acre-yields are found where corn occurs but once in a rotation. Where corn is grown twice in succession, the annual acre-yields are less; and where corn occurs three times, there is a further reduction. Also, the first crop of corn within a rotation produces more than the second, and the second crop yields more than the third. These are useful facts for consideration in connection with problems of general farm management.

YELLOW-GRAY SILT LOAM

Yellow-gray silt loam exhibits an important variation with respect to limestone content. In some areas, altho limestone may be altogether absent in the surface stratum it is found in abundance at a short distance beneath the surface. Accordingly, variations in response to soil treatment are exhibited by different experiment fields located on this type. In view of this discrepancy it is thought well to introduce here the records of two fields, that are representative of the type but which show a marked diversity in results, one in northern Illinois and one in the southern part of the state.

The Antioch field is located on the late Wisconsin glaciation, in Lake county, close to the Wisconsin border. The field was started in 1902, with but a single series of ten plots, under a rotation of corn, corn, oats, and wheat; but beginning with 1911 the rotation has been wheat, corn, oats, and clover. It was started in order to learn as quickly as possible what effect would be produced by the addition to this type of soil of nitrogen, phosphorus, and potassium, used singly and in combination. These elements were all applied in commercial form until 1911, after which the use of commercial nitrogen was discontinued and crop residues were substituted in its place. Nitrogen was supplied in the earlier years in 800 pounds per acre of dried blood. Phosphorus is applied in 200 pounds of steamed bone meal, and potassium in 100 pounds of potassium sulfate. At the beginning, 470 pounds of slaked lime was applied; but since 1912 limestone has been applied at the rate of 1,000 pounds per acre per year.

Table 6 presents, in summarized form, the results from the Antioch field. Because of an abnormality in Plot 1, the results from this plot are not considered. The data show that phosphorus is the one element standing out prominently as producing consistently beneficial results. Potassium applied in addition to phosphorus has, on the whole, not produced profitable results. Also, the

TABLE 6.—ANTIOCH FIELD: YELLOW-GRAY SILT LOAM, TIMBER SOIL; LATE WISCONSIN GLACIATION

Average Annual Yields—Bushels or (tons) per acre

Serial plot No.	Soil treatment applied	Corn 8 crops	Oats 5 crops	Wheat 4 crops	Clover seed 2 crops
1	0	23.9	32.3	15.8	.50
2	L	21.3	26.8	13.2	.30
3	LR	21.3	29.9	20.6	.33
4	LP	30.7	43.6	36.7	1.08
5	LK	23.7	27.8	19.2	.57
6	LRP	33.8	43.3	33.3	.57
7	LRK	24.3	26.9	20.8	.59
8	LPK	25.1	38.2	30.9	1.26
9	LRPK	38.3	42.6	28.0	.33
10	RPK	38.4	44.7	30.2	.67

Lime applied and residues plowed under

Lime and phosphorus applied

FIG. 4.—CLOVER IN 1913 ON ANTIOCH FIELD

results are unfavorable for the application of limestone. Limestone, however, is abundant in the subsoil of this type in the region of this field.

The **Raleigh** experiment field is located on the lower Illinoisan glaciation, in southern Illinois, in Saline county. This field is laid out into four series of ten plots each, under a rotation of wheat, corn, oats, and clover. The treatments, along with the summarized results, are given in Table 7.

In the rotation system in which limestone is being applied, no benefit of consequence to any of the crops except oats appears from the use of this material. The test, however, has hardly been of sufficient duration to warrant final conclusions; and furthermore, the comparison may be somewhat impaired by a possible residual effect of the small application of limestone made in 1903 to all the phosphorus plots.

The results obtained from the use of phosphorus are important because this element has been applied to these plots solely in the form of raw rock phosphate. The figures in almost every case show an increase in yield where the phosphorus has been applied, and in most cases this increase is very pronounced. The wheat is especially responsive to phosphorus.

The records furnish some interesting comparisons of corn yields produced under different systems of cropping. Table 5 gives a general summary of the corn yields only, in which the results from the residues and manure treatments are averaged together as "organic manures." The highest annual acre-yields are found where corn occurs but once in a rotation. Where corn is grown twice in succession, the annual acre-yields are less; and where corn occurs three times, there is a further reduction. Also, the first crop of corn within a rotation produces more than the second, and the second crop yields more than the third. These are useful facts for consideration in connection with problems of general farm management.

YELLOW-GRAY SILT LOAM

Yellow-gray silt loam exhibits an important variation with respect to limestone content. In some areas, altho limestone may be altogether absent in the surface stratum it is found in abundance at a short distance beneath the surface. Accordingly, variations in response to soil treatment are exhibited by different experiment fields located on this type. In view of this discrepancy it is thought well to introduce here the records of two fields, that are representative of the type but which show a marked diversity in results, one in northern Illinois and one in the southern part of the state.

The Antioch field is located on the late Wisconsin glaciation, in Lake county, close to the Wisconsin border. The field was started in 1902, with but a single series of ten plots, under a rotation of corn, corn, oats, and wheat; but beginning with 1911 the rotation has been wheat, corn, oats, and clover. It was started in order to learn as quickly as possible what effect would be produced by the addition to this type of soil of nitrogen, phosphorus, and potassium, used singly and in combination. These elements were all applied in commercial form until 1911, after which the use of commercial nitrogen was discontinued and crop residues were substituted in its place. Nitrogen was supplied in the earlier years in 800 pounds per acre of dried blood. Phosphorus is applied in 200 pounds of steamed bone meal, and potassium in 100 pounds of potassium sulfate. At the beginning, 470 pounds of slaked lime was applied; but since 1912 limestone has been applied at the rate of 1,000 pounds per acre per year.

Table 6 presents, in summarized form, the results from the Antioch field. Because of an abnormality in Plot 1, the results from this plot are not considered. The data show that phosphorus is the one element standing out prominently as producing consistently beneficial results. Potassium applied in addition to phosphorus has, on the whole, not produced profitable results. Also, the

Table 6.—ANTIOCH FIELD: Yellow-Gray Silt Loam, Timber Soil; Late Wisconsin Glaciation

Average Annual Yields—Bushels or (tons) per acre

Serial plot No.	Soil treatment applied	Corn 8 crops	Oats 5 crops	Wheat 4 crops	Clover seed 2 crops
1	0	23.9	32.3	15.8	.50
2	L	21.3	26.8	13.2	.30
3	LR	21.3	29.9	20.6	.33
4	LP	30.7	43.6	36.7	1.08
5	LK	23.7	27.8	19.2	.57
6	LRP	33.8	43.3	33.3	.57
7	LRK	24.3	26.9	20.8	.59
8	LPK	25.1	38.2	30.9	1.26
9	LRPK	38.3	42.6	28.0	.33
10	RPK	38.4	44.7	30.2	.67

Lime applied and residues plowed under

Lime and phosphorus applied

Fig. 4.—Clover in 1913 on Antioch Field

results are unfavorable for the application of limestone. Limestone, however, is abundant in the subsoil of this type in the region of this field.

The Raleigh experiment field is located on the lower Illinoisan glaciation, in southern Illinois, in Saline county. This field is laid out into four series of ten plots each, under a rotation of wheat, corn, oats, and clover. The treatments, along with the summarized results, are given in Table 7.

Manure, limestone, phosphorus
Yield: 61 bushels per acre

Nothing applied
Yield: 15 bushels per acre

FIG. 5.—CORN ON RALEIGH FIELD IN 1920

TABLE 7.—RALEIGH FIELD: YELLOW-GRAY SILT LOAM, TIMBER SOIL; LOWER ILLINOISAN GLACIATION

Average Annual Yields—Bushels or (tons) per acre

Serial plot No.	Soil treatment applied	Corn 10 crops	Oats 10 crops	Wheat 6 crops	Clover 4 crops		Soybeans 4 crops
1	0	17.3	10.4	5.8	(.26)		(.65)
2	M	29.7	13.0	7.7	(.31)		(.81)
3	ML	40.9	20.0	21.0	(1.08)		(1 08)
4	MLP	41.2	20 3	21.5	(1 32)		(1.24)
5	0	17.3	10.3	7.0	(.00)	.01[2]	2.3
6	R	20.1	12.8	8.4	(.00)	.01[2]	3.0
7	RL	34.9	21.5	18.8	(1.60)[1]	.10[2]	5.8
8	RLP	36 5	22 7	21.2	(1.61)[1]	.09[2]	6.8
9	RLPK	41.9	23.6	22.4	(1.79)[1]	.12[2]	6.0
10	0	19.6	11.6	6.5	(1.06)		(.57)

[1]One crop only (1920).
[2]Average of two crops.

The outstanding feature of these results is the effect of limestone. Altho manure alone produces a substantial increase, especially in the corn crop, when limestone is added a remarkable increase is found in all crops. A most important fact is that the organic matter can be effectively built up thru the use

of crop residues, with the application of limestone, so that the crop yields are practically as high under this "grain system" of farming as where manure is used.

Phosphorus thus far has given only moderate returns in increased crop yields, but with an increasing quantity of organic matter and nitrogen it is probable that the phosphorus applications will show up more favorably on subsequent crops. As to the use of potassium, it is to be noted that aside from an increase of 5.4 bushels of corn in the residues system, the beneficial effect has not been sufficient to justify the use of this material.

In accounting for the discrepancy in the response to limestone on these two fields, the fact is to be considered that the Antioch field is located on the late Wisconsin glaciation, where the subsoil contains large quantities of limestone; while the Raleigh field represents the lower Illinoisan glaciation, the soil of which is very acid to a great depth.

In view of these variations, a general recommendation for a complete treatment for soil of this type, that will apply to all localities, cannot be given out until more information is acquired.

Fortunately, however, each farmer can determine for himself the need of limestone for his land by applying the simple tests for the presence of carbonates and soil acidity, as explained under the discussion of limestone on page 29 of the Appendix.

Phosphorus, which has paid well on the Antioch field, and has given doubtful returns thus far at Raleigh, has varied considerably in its effect when used on other fields located on this same type of soil. In this situation, therefore, the present suggestion would be that each farmer might well try out phosphorus on his own land, on a limited scale, and be guided by the outcome of his experience. The low phosphorus content of the surface stratum of this soil is an indication that in a system of permanent agriculture the time is not far off when phosphorus will become a limiting element to crop production, and the wise farmer will watch carefully the indications and be ready to make timely provision for this need.

Deep Peat

As representing the deep peat type of soil, the results are introduced from an experiment field conducted at Manito in Mason county during the years 1902 to 1905 inclusive.

There were ten plots receiving the treatments indicated in Table 8.

The results of the four years' tests, as given in Table 8, are in complete harmony with the information furnished by the chemical composition of peat soil. Where potassium was applied, the yield was from three to four times as large as where nothing was applied. Where approximately equal money values of kainit and potassium chlorid were applied, slightly greater yields were obtained with the potassium chlorid, which, however, supplied about one-third more potassium than the kainit. On the other hand, either material furnished more potassium than was required by the crops produced.

The use of 700 pounds of sodium chlorid (common salt) produced no appreciable increase over the best untreated plots, indicating that where potassium is itself actually deficient, salts of other elements cannot take its place.

TABLE 8.—MANITO FIELD: DEEP PEAT
Corn Yields—Bushels

Plot No.	Soil treatment for 1902	Corn 1902	Corn 1903	Soil treatment for 1904	Corn 1904	Corn 1905	Four crops
1	None................	10.9	8.1	None................	17.0	12.0	48.0
2	None................	10.4	10.4	Limestone, 4000 lbs....	12.0	10.1	42.9
3	Kainit, 600 lbs........	30.4	32.4	Limestone, 4000 lbs.. / Kainit, 1200 lbs.....	49.6	47.3	159.7
4	Kainit, 600 lbs....... / Acidulat'd bone, 350 lb.	30.3	33.3	Kainit, 1200 lbs..... / Steamed bone, 395 lbs.	53.5	47.6	164.7
5	Potassium chlorid, 200 lbs............	31.2	33.9	Potassium chlorid, 400 lbs............	48.5	52.7	166.3
6	Sodium chlorid, 700 lbs.	11.1	13.1	None................	24.0	22.1	70.3
7	Sodium chlorid, 700 lbs.	13.3	14.5	Kainit, 1200 lbs.......	44.5	47.3	......
8	Kainit, 600 lbs........	36.8	37.7	Kainit, 600 lbs........	44.0	46.0	164.5
9	Kainit, 300 lbs........	26.4	25.1	Kainit, 300 lbs........	41.5	32.9	125.9
10	None................	14.9[1]	14.9	None................	26.0	13.6	69.4

[1]Estimated from 1903; no yield was taken in 1902 because of a misunderstanding.

Applications of 2 tons per acre of ground limestone produced no increase in the corn crops, either when applied alone or in combination with kainit, either the first year or the second.

Reducing the application of kainit from 600 to 300 pounds for each two-year period reduced the yield of corn from 164.5 to 125.9 bushels. The two applications of 300 pounds of kainit (Plot 9) furnished 60 pounds of potassium for the four years, an amount sufficient for 84 bushels of corn (grain and stalks). Attention is called to the fact that this is practically the difference between the yield of Plot 9 (125.9 bushels) and the yield obtained from Plot 2 (42.9 bushels), the poorest untreated plot.

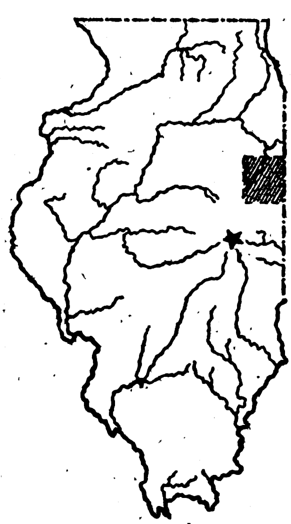
UNIVERSITY OF ILLINOIS

Agricultural Experiment Station

SOIL REPORT No. 22

IROQUOIS COUNTY SOILS

By J. G. MOSIER, S. V. HOLT, E. VAN ALSTINE
AND H. J. SNIDER
PREPARED FOR PUBLICATION BY L. H. SMITH



URBANA, ILLINOIS, JANUARY, 1922

IN RECOGNITION

The Soil Survey of Illinois was organized under the supervision of the late Dr. Cyril G. Hopkins. The work progressed for eighteen years under his guidance and the first eighteen soil reports bear his name as senior author. On October 6, 1919, Dr. Hopkins died in a foreign land in the service of the American Red Cross. It is the purpose to carry on to completion this great work of the Illinois Soil Survey in the spirit, and along the same general plan and lines of procedure, in which it was begun.

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INTRODUCTORY NOTE

It is a matter of common observation that soils vary tremendously in their productive power, depending upon their physical condition, their chemical composition, and their biological activities. For any comprehensive plan of soil improvement looking toward the permanent maintenance of our agricultural lands, a definite knowledge of the various existing kinds or types of soil is a first essential. It is the purpose of a soil survey to classify the various kinds of soil of a given area in such a manner as to permit definite characterization for description and for mapping. With the information that such a survey affords, every farmer or land owner of the surveyed area has at hand the basis for a rational system of improvement of his land. At the same time the Experiment Station is furnished an inventory of the soils of the state, upon which intelligently to base plans for those fundamental investigations so necessary for solving the problems of practical soil improvement.

This county soil report is one of a series reporting the results of the soil survey which, when completed, will cover the state of Illinois. Each county report is intended to be as nearly complete in itself as it is practicable to make it, even at the expense of some repetition. There is presented in the form of an Appendix a general discussion of the important principles of soil fertility, in order to help the farmer and land owner to understand the significance of the data furnished by the soil survey and to make intelligent application of the same in the maintenance and improvement of the land. In many cases it will be of advantage to study the Appendix in advance of the soil report proper.

Data from experiment fields representing the more extensive types of soil, and furnishing valuable information regarding effective practices in soil management, are embodied in form of a Supplement. This Supplement should be referred to in connection with the descriptions of the respective soil types found in the body of the report.

CONTENTS OF SOIL REPORT No. 22

IROQUOIS COUNTY SOILS

APPENDIX

SUPPLEMENT

IROQUOIS COUNTY SOILS

By J. G. MOSIER, S. V. HOLT, E. VAN ALSTINE, AND H. J. SNIDER

Prepared for Publication by L. H. SMITH[1]

FORMATION

Iroquois county is situated on the eastern border of Illinois about one hundred miles south of the north line. The county measures approximately thirty-three by thirty-four miles, and comprizes an area of 1,123.62 square miles.

The most important period in the geological history of the county from the standpoint of soil formation was that during which the material that later formed the soils was being deposited. This was the Glacial period. At that time snow and ice accumulated in the region of Labrador, west of Hudson Bay, and in the Rocky Mountains to such an amount that the mass pushed outward from these centers, especially southward, until a point was reached where the ice melted as rapidly as it advanced. As the ice advanced in these movements it buried everything, even the highest mountains, in its path. It would then recede slowly, and apparently normal conditions would be restored for a long period, after which another advance would occur. At least six of these great ice movements took place, each of which covered some part of northern United States, altho the same parts were not covered every time.

In advancing from these distant northern centers of accumulation, the ice gathered up all sorts and sizes of material, including clay, silt, sand, gravel, boulders, and even large masses of rock. Some of these materials were carried several hundred miles, and the coarser masses rubbed against the surface rocks or against each other until largely ground into rock powder, which now constitutes much of the soil. As the ice melted upon reaching the limit of advance, the material was dropped. If the glacier remained in the same position for some time, this material accumulated in a broad undulating ridge called a lateral moraine if formed at the side of the glacier, or a terminal moraine if formed at the end. When the ice melted more rapidly than the glacier advanced, the terminus of the glacier receded and the material was deposited somewhat irregularly over the land, back of the moraines. This formation is known as a ground moraine. A glacier would often advance again, but not so far as before; or it would remain stationary, and another moraine would be built up. These moraines, or ridges, have a steep outward slope and a very gradual inward slope.

A pressure of forty pounds per square inch is exerted by a mass of ice one hundred feet thick, and these ice sheets may have been hundreds or even thousands of feet in thickness. The materials carried along in the ice, especially the boulders and pebbles, became powerful agents for grinding and wearing away the surface over which the ice passed. Preglacial ridges and hills were rubbed

[1]J. G. Mosier, in charge of soil survey mapping; S. V. Holt, in charge of field party; E. Van Alstine, in charge of soil analysis; H. J. Snider, in charge of experiment fields; L. H. Smith, in charge of publications.

down, valleys were filled with the debris, and the surface features were changed entirely. The mixture of materials deposited by the glacier is known as boulder clay, till, glacial drift, or simply drift.

THE GLACIATIONS OF IROQUOIS COUNTY

There were at least four ice advances that reached Iroquois county and covered it wholly or in part. The first advance that reached this county was probably the Illinoisan glacier, which covered all of Illinois except the northwest corner (practically all of Jo Daviess county), the southern part of Calhoun county, and the seven southernmost counties. (See state map in Bulletin 123 or 193). This glacier melted and somewhat normal conditions were restored, as is indicated by the thick soil formed from the material deposited by the glacier.

The drift left by this ice sheet was buried by another glacier, probably the Iowan; and this was followed by a third, known as the early Wisconsin. The material deposited by the early Wisconsin glacier forms most of the surface material west of the Iroquois river and south of Sugar creek. The moraine appearing in the southeastern and southwestern parts of Iroquois and bending down into the northern part of Vermilion county is known as the Bloomington moraine. Another moraine was built up by the early Wisconsin glacier along the northern boundary of Kankakee county and west of the Iroquois river. This is known as the Marseilles moraine.

The late Wisconsin glacier covered most of the county east of the Iroquois river and north of Sugar creek. A more or less distinct moraine found here is called the Iroquois moraine. This moraine is quite characteristically developed near Beaverville in the northeastern part of the county.

PHYSIOGRAPHY AND DRAINAGE

The county varies in topography from flat to slightly rolling. Even along the streams hills do not exist to any extent. The principal variations are due to the irregular deposition of glacial material, the depth of which varies from a few feet to more than three hundred feet, and averages probably about one hundred and fifty feet. The moraines take the form of irregular billowy ridges, and they vary in width from a mile or two, to six or eight miles. A broad flat valley, comprizing a large part of the intermorainal area, lies between the three moraines. This valley was formerly very poorly drained. It contained extensive swamps and many ponds, which usually became dry during the summer. The marginal ridges, with the underlying sands and gravels of this valley or basin, have brought about conditions that give rise to artesian wells. Water is obtained at depths varying from 30 to 160 feet.

With the exception of a few small areas in the northwest part, the entire county is drained by the Iroquois river and its tributaries, the principal of which are the Langum, Prairie, and Spring creeks from the west, with Sugar, Pike, and Beaver from the east. These streams, together with the dredge ditches which have been made, now provide a very good system of drainage. Erosion topography is limited to the immediate vicinity of the streams. In some places the subsoil becomes too heavy and tight for good drainage.

Peaty loam on sand

Deep peat

SOIL SURVEY MAP OF IROQUOIS COUNTY

ATION

MAP SHOWING THE DRAINAGE BASINS OF IROQUOIS COUNTY WITH MORAINAL, INTERMORAINAL, AND TERRACE AREAS

The altitudes of several places in Iroquois county are as follows: Ashkum, 670 feet above sea level; Buckley, 702; Chebanse, 674; Cissna Park, 684; Cissna Junction, 690; Claytonville, 665; Clifton, 672; Crescent City, 637; Danforth, 658; Donovan, 670; Del Ray, 669; Fountain Creek, 677; Gilman, 654; Goodwine, 660; Hickman, 677; Iroquois, 673; Loda, 780; LaHogue, 664; Martinton, 627; Milford, 666; Onarga, 676; Papineau, 630; Pittwood, 643; Sheldon, 688; Stockland, 695; Thawville, 696; Watseka, 634; Woodland, 640; Wellington, 698.

During the Glacial period, the drainage of the Great Lakes to the north and east was blocked by the ice, and the water necessarily found an outlet to the south thru the Illinois and Wabash rivers. The former drained Lake Michigan and Lake Huron in part, while the latter drained Lake Erie. At that time the basins of the Iroquois and Kankakee were temporary broad lakes. That of the Iroquois extended from Onarga to the Marseilles moraine and westward across Ford county into Livingston county, and it probably overflowed into the Vermilion river and thence to the Illinois river. These lakes were shallow and did not exist for any great length of time. They were succeeded by swamps that have been only recently drained.

SOIL MATERIAL AND SOIL TYPES

The glaciers that covered Iroquois county left a deposit called till, glacial drift, or boulder clay (a mixture of boulders, gravel, sand, silt, and clay), having an average thickness of about 150 feet. This deposit, however, does not form the soil material except in small areas. The rock flour produced by the grinding action of the glaciers was reworked by the wind and deposited over practically all of the county to a depth of 12 to 40 inches. This loessial, or wind-blown material now covering the level and less rolling areas, has been transformed into soil by weathering and by the accumulation of organic matter. There is little doubt but that this wind-blown material was at one time fairly uniformly deposited over the exposed surface, but it has subsequently been removed in places by erosion, so that the boulder clay is exposed on some of the more rolling areas. The deposit is thicker on the early Wisconsin glaciation than on the late Wisconsin, because of a deeper original deposit (3 to 6 feet) and because there has not been so much erosion on this less rolling area.

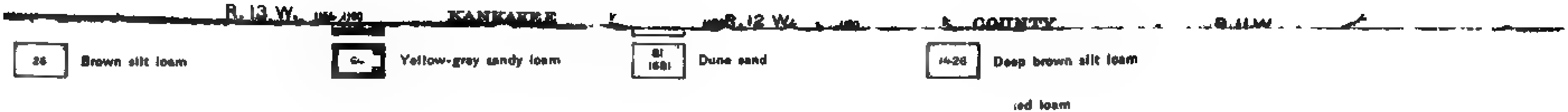
During the melting of the glacier the streams draining this area were frequently flooded and carried large amounts of rather coarse material, such as gravel and sand. This was deposited in the valleys, partly filling them. Later the streams cut down thru the fill, leaving gravel terraces. This gravel was later covered with the fine material that now constitutes the soil. These terraces occur principally along Sugar creek, and in broad irregular expansions along the Iroquois river and to the northeast part of the county along Beaver creek. Part of this area, constituting the expansion south of Martinton, was produced by the breaking of the water over the moraine south and east of Hooper. Much sand was deposited by this overflow and this area south of Martinton contains many sand dunes.

The soils of Iroquois county are divided into the following groups:

(a) Upland Prairie Soils, including the upland soils that have not been covered with forests and on which the luxuriant growth of prairie grasses has produced relatively large amounts of organic matter.

(b) Upland Timber Soils, including nearly all the upland areas that are now, or were formerly, covered with forests.

(c) Terrace Soils, including bench lands, or second bottom lands, formed by deposits from overloaded streams, or by broad sheets of water arising from the melting of the glaciers.



'OUNTY
MENT STATION

(*d*) *Swamp and Bottom-Land Soils*, including the overflow lands or flood plains along streams, the swamps, and the poorly drained lowlands.

Table 1 gives a list of the types of soil found in Iroquois county, the area of each type in square miles and in acres, and its percentage of the total area. For example, it may be noted that the brown silt loam of the prairie occupies sixty percent of the area of the county. The accompanying map shows the location and boundary of each type of soil, even down to areas of a few acres.

For explanations concerning the classification of soils and the interpretation of the map and tables, the reader is referred to the first part of the Appendix to this report.

TABLE 1.—SOIL TYPES OF IROQUOIS COUNTY, ILLINOIS

Soil type No.	Name of type	Area in square miles	Area in acres	Percent of total area
	(a) Upland Prairie Soils (900, 1000, 1100, 1200)			
-26	Brown silt loam	681.81	436,358	60.68
-20	Black clay loam	80.46	51,494	7.16
-60	Brown sandy loam	106.37	68,077	9.45
-81	Dune sand	4.65	2,976	.41
-28	Brown-gray silt loam on tight clay	1.33	851	.12
-28.1	Brown silt loam on tight clay	7.36	4,710	.66
		881.98	564,466	78.48
	(b) Upland Timber Soils (900, 1000, 1100, 1200)			
-34	Yellow-gray silt loam	16.74	10,714	1.49
-64	Yellow-gray sandy loam	4.48	2,867	.40
-35	Yellow silt loam	1.58	1,011	.14
-38	Yellow-gray silt loam on tight clay	1.60	1,024	.14
		24.40	15,616	2.17
	(c) Terrace Soils (1500)			
-60	Brown sandy loam	108.30	69,312	9.64
-26	Brown silt loam	2.66	1,702	.24
-27	Brown silt loam over gravel	13.20	8,448	1.18
-64	Yellow-gray sandy loam	9.14	5,850	.81
-81	Dune sand	18.50	11,840	1.65
-34	Yellow-gray silt loam	.46	294	.04
-36	Yellow-gray silt loam over gravel	6.37	4,077	.57
-66	Brown sandy loam over gravel	4.98	3,187	.44
-67	Yellow-gray sandy loam over gravel	3.30	2,112	.29
-26.4	Brown silt loam on gravel	.33	211	.03
-20	Black clay loam	.25	160	.02
		167.49	107,193	14.91
	(d) Swamp and Bottom-Land Soils (1400)			
-26	Deep brown silt loam	29.06	18,599	2.59
-54	Mixed loam	3.88	2,483	.35
-61	Black sandy loam	12.61	8,071	1.12
-10.2	Peaty loam on sand	.45	288	.04
-01	Deep peat	1.78	1,139	.16
-02	Medium peat on clay	.73	467	.07
-13	Clayey muck	.25	160	.02
		48.76	31,207	4.35
	Water	.99	634	.09
	Total	1,123.62	719,116	100.00

INVOICE OF PLANT FOOD IN IROQUOIS COUNTY SOILS

SOIL ANALYSIS

The composition reported in the accompanying tables is, for the more extensive types, the average of several analyses. These analyses, like most things in nature, show more or less variation, but for general purposes they may be considered sufficient to characterize the soil type.

The chemical analysis of a soil, obtained by the methods here employed, gives the invoice of the total stock of the several plant-food materials actually present in the soil strata sampled and analyzed, but it should be understood that the rate of liberation, as explained in the Appendix (page 35), is governed by many factors.

THE SURFACE SOIL

In Table 2 are reported the amount of organic carbon (the best measure of the organic matter), and the total quantities of nitrogen, phosphorus, sulfur, potassium, magnesium, and calcium contained in 2 million pounds of the surface soil (the plowed soil of an acre about 6⅔ inches deep) of each type in Iroquois county.

Because of the fact that soils often vary so extremely within the type with respect to the presence of limestone and acidity, no attempt is made to include in the tabulated results figures purporting to represent the average amounts of these substances present in the respective types. Such averages cannot give the farmer the specific information he needs regarding the lime requirements of a given field. Fortunately, however, very simple tests which can be made at home will furnish this important information, and these tests are described on page 37 of the Appendix.

The variation among the different types of soil with respect to the content of important plant-food elements is very marked. For example, the deep peat contains, in the plowed soil of an acre, more than thirty times as much nitrogen as does the dune sand. Comparing the deep peat with the most common type in the county, we find about five times as much nitrogen in it as in the brown silt loam, while on the other hand the brown silt loam contains more than eight times as much potassium as is found in the deep peat. The supply of phosphorus in the surface soil varies from 660 pounds per acre in the dune sand to 1,450 pounds in the deep brown silt loam. A sulfur content of 190 pounds per acre is found in the dune sand, while in the deep peat there are 4,310 pounds of this element. The magnesium varies in the different types from 2,900 to 18,280 pounds, and the calcium content ranges from 5,700 to 24,840 pounds per acre.

It is important to note that some of the plant-food elements are present in very limited quantities as compared with crop requirements. Some simple computations are of interest in this connection. Assume, for example, that a four-field crop rotation of wheat, corn, oats, and clover yields 50 bushels of wheat per acre, 100 bushels of corn, 100 bushels of oats, and 4 tons of clover hay. It will be found that the most prevalent upland soil of Iroquois county, the brown silt loam, contains only enough total nitrogen in the plowed soil for the production of such yields to supply about ten rotations.

TABLE 2.—PLANT FOOD IN THE SOILS OF IROQUOIS COUNTY, ILLINOIS: SURFACE SOIL
Average pounds per acre in 2 million pounds of surface soil (about 0–6⅔ inches)

Soil type No.	Soil type	Total organic carbon	Total nitrogen	Total phosphorus	Total sulfur	Total potassium	Total magnesium	Total calcium
	(a) Upland Prairie Soils (900, 1000, 1100, 1200)							
-26, 1526	Brown silt loam	65 020	5 300	1 060	920	39 700	10 590	10 670
-20	Black clay loam	65 260	6 160	1 310	1 030	42 260	16 600	19 450
-60	Brown sandy loam	57 880	4 700	1 270	990	23 900	6 390	24 840
-81, 1581	Dune sand	13 710	900	660	190	26 570	3 120	7 360
1128	Brown-gray silt loam on tight clay	44 180	3 840	1 060	760	32 320	7 060	8 260
1128.1	Brown silt loam on tight clay	46 860	4 240	860	460	39 900	9 620	10 020
	(b) Upland Timber Soils (900, 1000, 1100, 1200)							
-34	Yellow-gray silt loam	24 460	1 970	880	270	39 740	5 280	6 850
-64	Yellow-gray sandy loam	25 560	2 040	700	300	30 000	3 480	7 180
-35	Yellow silt loam	28 370	2 680	810	350	59 600	16 170	6 460
-38	Yellow-gray silt loam on tight clay	33 600	3 200	970	530	33 680	6 390	6 490
	(c) Terrace Soils (1500)							
-60	Brown sandy loam	55 770	4 880	1 170	990	23 610	5 020	16 970
-26, 926, 1026, 1126, 1226	Brown silt loam	65 020	5 300	1 060	920	39 700	10 590	10 670
-27	Brown silt loam over gravel	51 280	4 600	1 240	700	30 400	5 580	6 240
-64	Yellow-gray sandy loam	21 660	1 820	740	200	27 680	3 480	6 220
-81, 981, 1081, 1181, 1281	Dune sand	13 710	900	660	190	26 570	3 120	7 360
-34	Yellow-gray silt loam	34 620	3 040	1 040	400	46 420	9 580	8 560
-36	Yellow-gray silt loam over gravel	28 180	2 310	1 060	290	39 140	5 640	6 330
-66	Brown sandy loam over gravel	34 250	2 920	1 000	650	29 160	4 970	7 450
-67	Yellow-gray sandy loam over gravel	21 040	1 420	760	360	27 860	3 240	5 700
-26.4	Brown silt loam on gravel	35 720	2 880	1 080	380	28 240	5 280	6 000
-20	Black clay loam	57 980	5 220	1 380	760	34 760	14 440	17 320
	(d) Swamp and Bottom-Land Soils (1400)							
-26	Deep brown silt loam	70 060	5 860	1 450	1 320	46 770	18 280	22 280
-54	Mixed loam	77 040	6 700	1 280	1 800	28 620	6 800	9 060
-61	Black sandy loam	65 290	5 730	1 230	1 000	30 210	7 990	19 960
-10.2	Peaty loam on sand[1]	172 320	13 350	870	2 430	17 450	5 250	19 170
-01	Deep peat[2]	345 060	27 910	1 160	4 310	4 590	3 010	23 410
-02	Medium peat on clay[2]	211 120	16 040	730	2 990	8 600	2 900	18 660
-13	Clayey muck[1]	151 950	13 070	1 440	3 170	32 840	11 390	17 810

Limestone and Soil Acidity.—In connection with these tabulated data it should be explained that the figures on limestone content and soil acidity are omitted not because of any lack of importance of these factors, but rather because of the peculiar difficulty of presenting in general averages adequate information concerning the limestone requirement. The limestone requirement for soils is extremely variable. It may vary from farm to farm, and even from field to field. Therefore no attempt is made to include in these tables figures purporting to represent for the various types the limestone content or the soil acidity present. The need for limestone should be determined on every farm and for each field individually. Fortunately this can be easily done by the simple tests described in the Appendix to this report, page 37.

[1]Amounts reported are for 1½ million pounds of peaty loam and clayey muck.
[2]Amounts reported are for 1 million pounds of deep peat and medium peat.

TABLE 3.—PLANT FOOD IN THE SOILS OF IROQUOIS COUNTY, ILLINOIS: SUBSURFACE SOIL
Average pounds per acre in 4 million pounds of subsurface soil (about 6⅔-20 inches)

Soil type No.	Soil type	Total organic carbon	Total nitrogen	Total phosphorus	Total sulfur	Total potassium	Total magnesium	Total calcium
	(a) Upland Prairie Soils (900, 1000, 1100, 1200)							
-26, 1526	Brown silt loam	60 530	5 280	1 430	1 080	84 710	28 420	18 920
-20	Black clay loam	60 110	5 720	2 020	1 140	87 590	38 080	38 940
-60	Brown sandy loam	45 700	4 160	1 700	1 020	51 340	14 120	42 960
-81, 1581	Dune sand	14 860	960	1 100	320	52 480	6 000	13 420
1128	Brown-gray silt loam on tight clay	49 240	4 280	1 440	760	76 280	19 520	13 520
1128.1	Brown silt loam on tight clay	47 200	4 640	1 200	480	84 200	25 080	15 080
	(b) Upland Timber Soils (900, 1000, 1100, 1200)							
-34	Yellow-gray silt loam	16 800	1 680	1 480	360	72 780	16 380	11 840
-64	Yellow-gray sandy loam	16 520	1 320	1 360	280	59 920	8 000	15 800
-35	Yellow silt loam	24 440	3 380	1 760	580	139 300	70 560	65 140
-38	Yellow-gray silt loam on tight clay	27 580	3 140	1 300	500	77 880	23 980	10 520
	(c) Terrace Soils (1500)							
-60	Brown sandy loam	41 940	3 710	1 550	850	51 250	11 050	25 270
-26, 926, 1026, 1126, 1226	Brown silt loam	60 530	5 280	1 430	1 080	84 710	28 420	18 920
-27	Brown silt loam over gravel	49 120	4 720	1 760	720	64 280	13 720	10 080
-64	Yellow-gray sandy loam	11 360	1 200	1 200	280	58 000	9 640	11 080
-81, 981, 1081, 1181, 1281	Dune sand	14 860	960	1 100	320	52 480	6 000	13 420
-34	Yellow-gray silt loam	32 440	3 320	1 600	520	99 680	31 960	11 400
-36	Yellow-gray silt loam over gravel	18 980	2 180	1 620	240	84 660	18 740	10 520
-66	Brown sandy loam over gravel	36 680	3 400	1 490	730	60 280	11 590	13 210
-67	Yellow-gray sandy loam over gravel	13 240	1 040	1 360	600	62 800	9 080	10 160
-26.4	Brown silt loam on gravel	38 160	3 400	1 600	480	59 680	11 640	9 840
-20	Black clay loam	51 720	4 800	2 080	720	68 880	28 920	36 160
	(d) Swamp and Bottom-Land Soils (1400)							
-26	Deep brown silt loam	118 740	10 320	2 680	2 080	91 660	32 900	35 380
-54	Mixed loam	33 280	3 080	1 040	600	62 280	11 680	13 960
-61	Black sandy loam	45 020	4 220	1 080	1 120	64 940	17 040	27 780
-10.2	Peaty loam on sand[1]	149 670	9 450	1 230	2 460	41 640	12 000	36 120
-01	Deep peat[2]	354 540	30 940	1 360	6 180	17 640	8 260	32 740
-02	Medium peat on clay[2]	114 180	8 820	820	2 120	23 360	4 600	18 360
-13	Clayey muck[1]	329 310	27 270	2 100	7 590	51 540	24 180	44 100

Limestone and Soil Acidity.—In connection with these tabulated data it should be explained that the figures on limestone content and soil acidity are omitted not because of any lack of importance of these factors, but rather because of the peculiar difficulty of presenting in general averages adequate information concerning the limestone requirement. The limestone requirement for soils is extremely variable. It may vary from farm to farm, and even from field to field. Therefore no attempt is made to include in these tables figures purporting to represent for the various types the limestone content or the soil acidity present. The need for limestone should be determined on every farm and for each field individually. Fortunately this can be easily done by the simple tests described in the Appendix to this report, page 37.

[1]Amounts reported are for 3 million pounds of peaty loam and clayey muck.
[2]Amounts reported are for 2 million pounds of deep peat and medium peat.

TABLE 4.—PLANT FOOD IN THE SOILS OF IROQUOIS COUNTY, ILLINOIS: SUBSOIL
Average pounds per acre in 6 million pounds of subsoil (about 20-40 inches)

Soil type No.	Soil type	Total organic carbon	Total nitrogen	Total phosphorus	Total sulfur	Total potassium	Total magnesium	Total calcium
	(a) Upland Prairie Soils (900, 1000, 1100, 1200)							
-26, 1526	Brown silt loam	29 150	3 300	2 020	1 180	147 660	86 810	107 680
-20	Black clay loam	26 590	3 600	2 780	3 180	129 590	83 100	167 860
-60	Brown sandy loam	24 690	3 360	1 860	840	87 420	23 970	42 150
-81, 1581	Dune sand	13 290	1 020	1 620	360	80 220	9 690	20 730
1128	Brown-gray silt loam on tight clay	30 720	3 540	1 620	1 020	140 160	49 680	24 540
1128.1	Brown silt loam on tight clay	26 880	4 020	2 340	660	148 980	77 520	115 740
	(b) Upland Timber Soils (900, 1000, 1100, 1200)							
-34	Yellow-gray silt loam	12 360	1 800	2 070	300	116 970	35 610	20 670
-64	Yellow-gray sandy loam	11 760	1 020	1 800	300	85 260	14 400	21 300
-35	Yellow silt loam	24 900	3 600	2 370	840	183 990	127 680	203 880
-38	Yellow-gray silt loam on tight clay	21 750	3 690	2 100	930	142 230	61 500	22 800
	(c) Terrace Soils (1500)							
-60	Brown sandy loam	17 800	2 070	1 800	650	83 230	24 400	42 760
-26, 926, 1026, 1126, 1226	Brown silt loam	29 150	3 300	2 020	1 180	147 660	86 810	107 680
-27	Brown silt loam over gravel	23 400	2 760	2 280	1 020	93 900	28 080	20 400
-64	Yellow-gray sandy loam	15 720	2 220	1 800	240	114 720	31 200	18 360
-81, 981, 1081, 1181, 1281	Dune sand	13 290	1 020	1 620	360	80 220	9 690	20 730
-34	Yellow-gray silt loam	21 960	3 000	2 280	720	139 980	42 300	20 460
-36	Yellow-gray silt loam over gravel	15 060	2 250	1 890	240	119 970	32 310	20 160
-66	Brown sandy loam over gravel	22 920	2 580	1 840	580	99 760	24 560	24 200
-67	Yellow-gray sandy loam over gravel	13 320	1 920	2 220	240	105 300	22 860	15 840
-26.4	Brown silt loam on gravel	19 620	2 160	1 980	180	90 420	19 980	13 380
-20	Black clay loam	23 880	2 640	2 100	600	98 040	91 320	249 600
	(d) Swamp and Bottom-Land Soils (1400)							
-26	Deep brown silt loam	83 490	7 590	2 880	1 590	236 680	43 410	39 240
-54	Mixed loam	22 980	2 220	960	420	102 420	22 320	17 880
-61	Black sandy loam	16 710	2 250	1 950	960	100 920	32 580	41 670
-10.2	Peaty loam on sand	19 740	1 140	1 560	1 560	68 820	34 320	271 560
-01	Deep peat[1]	298 020	23 100	1 500	31 140	38 970	25 650	75 330
-02	Medium peat on clay	92 160	6 300	1 800	4 860	78 840	27 960	74 940
-13	Clayey muck	355 860	23 760	2 340	9 600	116 700	62 640	79 020

Limestone and Soil Acidity.—In connection with these tabulated data it should be explained that the figures on limestone content and soil acidity are omitted not because of any lack of importance of these factors, but rather because of the peculiar difficulty of presenting in general averages adequate information concerning the limestone requirement. The limestone requirement for soils is extremely variable. It may vary from farm to farm, and even from field to field. Therefore no attempt is made to include in these tables figures purporting to represent for the various types the limestone content or the soil acidity present. The need for limestone should be determined on every farm and for each field individually. Fortunately this can be easily done by the simple tests described in the Appendix to this report, page 37.

[1]Amounts reported are for 3 million pounds of deep peat.

With respect to phosphorus, the condition differs only in degree, this soil containing no more of that essential element than would be required for about thirteen crop rotations yielding at the rates suggested above. On the other hand the amount of potassium in the surface layer of this common soil type is sufficient for more than 31 centuries if only the grain is sold, or for more than 600 years if the total crops should be removed from the land and nothing returned.

These general statements relating to the total quantities of these plant-food materials in the plowed soil of the most prevalent type in the county certainly emphasize the fact that the supplies of some of these necessary elements of fertility are extremely limited when measured by the needs of large crop yields for even one or two generations of people.

THE SUBSURFACE AND SUBSOIL

In Tables 3 and 4 are recorded the amounts of plant food in the subsurface and the subsoil of the different types. It should be remembered, however, that these supplies are of little value unless the top soil is kept rich. These tables also show great stores of potassium in the prevailing types of soil but only limited amounts of nitrogen and phosphorus, in agreement with the data for the corresponding surface samples.

DESCRIPTION OF INDIVIDUAL SOIL TYPES

(a) UPLAND PRAIRIE SOILS

The upland prairie soils of Iroquois county cover 882 square miles, or 78.5 percent of the area of the county. They usually occupy the less eroded areas of the upland. They are black or brown in color, owing to their high organic-matter content. This land was originally covered with prairie grasses the partially decayed roots of which have been the source of the organic matter. The flat, poorly drained areas contain the greater amounts of organic matter, owing to the more luxuriant growth of the grasses there and to the excessive moisture in the soil which provided conditions better adapted for the preservation of their roots.

Brown Silt Loam (926, 1026, 1126, 1226)

Brown silt loam is the most extensive type in Iroquois county, some townships in the southern part being made up entirely of this type, while others are brown silt loam interspersed with a few very small areas of black clay loam. It covers an area of 681.81 square miles, or practically 60 percent of the area of the county. It is found on land which varies in topography from flat to slightly rolling. The more rolling phase is found in the northwest part of the county and on the moraines in the vicinity of Beaverville in the northeast part.

While this is primarily a prairie type, timber has recently invaded it to a slight extent in some localities. The trees found on the timbered brown silt loam are usually bur oak, wild cherry, black walnut, ash, and elm, but their occupation of the soil has not been sufficiently long to change its character to any great extent.

The surface soil, 0 to 6⅔ inches, is a brown silt loam varying from a yellowish brown on the more rolling areas to a dark brown or black on the more nearly level and poorly drained tracts. In physical composition it varies to some extent; but it normally contains from 55 to 75 percent of the different grades of silt. In the lower areas the proportion of clay is usually higher than on the more rolling parts, where a perceptible amount of sand may occur. With the flooding of a very large part of the county during the time of the melting of the glacier, more or less sand was carried in and deposited on some of the lower parts, altho much of this has received a deposit of fine silt and clay. Some of the sand was carried to the higher lands by the wind and became mixed with the soil, forming a sandy loam or a sandy phase of the silt loam.

The organic-matter content of the surface soil varies from about 4 to 6 percent, depending on topography, and averages about 5.3 percent, or 53 tons per acre. In small areas on the more rolling parts of the moraines erosion has occurred to such an extent that the type has been changed, but these areas are not large enough to map. In this county the organic-matter content is about the same in amount in the early and the late Wisconsin glaciations.

The natural subsurface is represented by a stratum which varies from 6 to 16 inches in thickness. This variation is due either to erosion, or to the fact that more shallow-rooting grasses usually grew on the higher and better-drained land, or to both of these causes. Erosion removed some of the surface soil from the steeper parts and deposited it on the lower land, thus leaving a thinner layer of the dark soil in one case and producing a thicker one in the other. The physical composition of the subsurface varies in somewhat the same manner as the surface. In some parts, especially on the moraines of the late Wisconsin glaciation, the glacial till constitutes part or all of the subsurface soil.

The organic-matter content is about the same in both glaciations, but varies with topography the same as the surface soil. The average is about 2.6 percent, or 52 tons per acre in a stratum twice the thickness of the surface soil. In color the subsurface varies from a yellowish brown to dark brown or almost black, always changing to a lighter color with increasing depth.

The natural subsoil begins at a depth of 12 to 22 inches and extends to an indefinite depth but is sampled from 20 to 40 inches. It varies from a yellow to a drabbish yellow, silty, clayey material, sometimes composed wholly or in part of boulder clay. This applies especially to the late Wisconsin glaciation. In the flat areas that are not subject to erosion, but where material has been washed in from the higher surrounding land, the subsoil to a depth of 40 inches may not reach the boulder clay.

In general, the three strata of this type are formed from either wind-blown loessial material, boulder clay, or from material deposited in shallow water. A phase of brown silt loam is found on the moraines in the county where, because of the removal of part of the fine loessial material, the glacial drift is encountered at less than 30 inches from the surface. If the drift is quite compact, as is occasionally the case, this gives rise to a subsoil that is somewhat inferior, owing to its less pervious character. This condition, however, does not occur very frequently nor does it include large areas, since most of the glacial drift is pervious and some is even gravelly.

Management.—Originally when the virgin brown silt loam was first cropped, it was in fine tilth, worked easily, and large crops could be grown with much less work than now. Continuous cropping to corn, or to corn and oats, with the burning of corn stalks, stubble, grass, and even straw in many cases, has in a great measure destroyed the tilth, so that now the soil is more difficult to work, washes rather badly, runs together, and bakes more readily than formerly. Unless the moisture conditions are very favorable, the ground will plow up cloddy, with the result that unless well-distributed rains follow, a good seed bed is difficult to produce. The clods may remain all season. Much plant food will be locked up in them, and the best results cannot be obtained. This condition of poor tilth may become serious if the present methods of management continue; in some cases it is already one of the factors that limits crop yields. The remedy is to use a rotation having a clover crop and to increase the organic-matter content by plowing under every available form of vegetable material, such as farm manure, corn stalks, straw, clover, stubble, and even weeds. Fresh organic matter is not only of great value in improving the physical condition of this type of soil, but it is equally important because of its nitrogen content, and also because of its power, as it decays, to liberate potassium from the inexhaustible supply in the soil, and phosphorus from the phosphate contained in or applied to the soil.

The deficiency of organic matter in the soil is shown by the way the fall-plowed land runs together during the winter, or at any time when heavy rains occur. Fall-plowed land should be disked early and deep for the purpose of conserving moisture, raising the temperature, and making plant food available.

For permanent, profitable systems of farming on brown silt loam, phosphorus should be applied liberally, and sufficient organic matter should be provided to furnish the necessary amount of nitrogen. On the ordinary phase of the type limestone is already becoming deficient in the upper strata altho it often exists in considerable quantity in the subsoil. For the permanent improvement of this soil an application of 2 tons of limestone and ½ ton of finely ground rock phosphate per acre about every four years should be made, with the return to the soil of all manure made in a rotation.

Suggestions for practical systems of cropping will be found in the discussion of crop rotations in the Appendix, on page 42. For the results of actual field experiments in improving the soil of the brown silt loam type the reader is referred to page 46 of the Supplement.

Black Clay Loam (920, 1120)

Black clay loam represents the flat prairie land that was formerly swampy. It is sometimes called "gumbo" because of its sticky character. Its occurrence in the flat poorly drained areas is due to the accumulation of organic matter and to the washing in of clay and fine silt from the higher adjoining areas. Aside from a large body of this type found in the northwest part of the county, black clay loam occurs mainly in the south-central part, scattered about in small areas. This type occupies 80.46 square miles, or 7.16 percent of the area of the county.

The surface soil, 0 to 6⅔ inches, is a black, plastic, granular, clay loam varying locally to a black clayey silt loam, or even to a black sandy clay loam. In physical composition, it varies somewhat as it grades into other types. Often it contains a perceptible amount of sand, and even gravel may be present. In some places that were formerly sloughs the water has deposited gravel in sufficient abundance to form a gravelly black clay loam. The organic-matter content varies from 4.7 to 6.4 percent, with an average of 5.5 percent, or 55 tons per acre.

The natural subsurface stratum has a thickness of 10 to 16 inches. It varies from a black to a brownish drab clay loam and is usually somewhat heavier than the surface soil. It grades into a dull yellow or a drabbish or olive-colored material with depth. The average organic-matter content of the stratum sampled (6⅔ to 20 inches) is about 2.4 percent, or 48 tons per acre. The stratum is usually rather pervious to water, owing to jointing or checking from shrinkage in times of drouth, to the penetration of plant roots, and to the action of crayfish and other animals. Some exceptions to this are found where it grades toward brown-gray silt loam on tight clay (1128) and brown silt loam on tight clay (1128.1). Here the lower strata become somewhat impervious and drainage is slow. These areas occur principally west of the Iroquois river in Townships 27 and 28 North.

The subsoil to a depth of 40 inches varies in composition from a clayey silt to a very heavy clay, and in color from a dull drabbish yellow to drab or olive. Because of poor natural drainage, the iron in the subsoil is not highly oxidized. Concretions of lime carbonate are frequently found. The perviousness of the subsoil is about the same as that of the subsurface and is due to the same causes. When thrown out on the surface where wetting and drying may take place, it soon breaks into small irregular masses about one-fourth to one-half inch square.

The black clay loam presents many variations. It may change with a difference of only a foot or two in elevation. In this county, as elsewhere, the boundary lines between the black clay loam and the brown silt loam are not always distinct. Sometimes on the border between these two types the subsoil is distinctly that of black clay loam, while the surface soil is very silty, or is a good brown silt loam. The washing in of silty material from the surrounding higher lands, especially near the edges of the areas, modifies the character of the soil, giving it a brown silt loam surface. With the annual cultivation of the soil this change is taking place more rapidly now than formerly when washing was largely prevented by prairie grasses. Many small areas of black clay loam in the more rolling parts are being slowly buried by this process.

The areas of heavier subsoil are found in Townships 27 and 28 North, Ranges 10 and 11 East, and 13 and 14 West. This constitutes an old lake floor which was covered with a deposit of very fine material.

Management.—Drainage is the first requirement in the management of this type and, if the outlet is obtainable, this may usually be accomplished with little difficulty. An exception is found west of the Iroquois river in parts of Townships 27 and 28, where drainage is prevented by tight clay subsoil. Thoro drainage helps to keep the soil in good physical condition and is very necessary. After the organic matter is necessarily destroyed by the process of nitrification,

and after the limestone is removed by cropping and leaching, the physical condition of the soil becomes poorer, and as a consequence more difficult to work. Both organic matter and limestone tend to develop granulation and mellowness, which are very essential with heavy soils. The organic matter should be maintained by turning under manure and such crop residues as corn stalks and straw, and by the use of clover and pasture in rotations.

The use of limestone will probably be of little or no value on most of this soil because the subsoil and subsurface are usually naturally charged with carbonates. Because of possible exceptions to this condition, however, it is recommended that the test for the presence of carbonates described in the Appendix, page 37, be made; and if carbonates are not found within a foot of the surface, a moderate application of limestone, say 2 tons per acre, should be made.

For building up this type of soil to its highest state of fertility the phosphorus content ought to be increased. This may be well accomplished by the use of rock phosphate applied at the rate of one-half ton per acre once during each crop rotation.

While the black clay loam is one of the most productive soils in the state, yet its high content of clay and humus imparts a tendency to shrink and expand to such a degree as to be objectionable at times, especially during drouth. The clay and humus expand when the soil is wet, and shrink when the moisture evaporates or is used by the growing crop. This results in the formation of cracks, which are sometimes as much as two or more inches in width at the surface and extend with lessening width to two or three feet in depth. These cracks allow the soil to dry out more rapidly, and as a result the crop is injured thru lack of moisture. They do much damage by "blocking out" hills of corn and severing the roots. While cracking may not be prevented entirely, good tilth with a soil mulch will do much toward that end.

Cultivation is more essential on this type, both for aeration and for the conservation of moisture, than on almost any other type in the county. It must be remembered, however, that cultivation should be as shallow as possible in order to prevent injury to the roots of corn. (See Bulletin 181.)

Occasional small patches of alkali soil are found in areas of black clay loam. These spots are indicated by the fact that oats lodge badly and corn makes a poor growth, usually turning yellow or brown. If the amount of alkali is large, the corn may not grow to a height of more than two or three feet and will have a bushy appearance. Even if it reaches almost normal height, it does not produce much grain. The fragments of shells that are frequently found are indications of alkali.

The results of field experiments on black clay loam are given on page 54 of the Supplement.

Brown Sandy Loam (960, 1060, 1160, 1260)

The brown sandy loam of the upland is confined very largely to the northern three-fifths of the county. The southern two tiers of townships contain comparatively small areas, the largest being in the east part along Mud and Sugar creeks. Much the larger area is found in the northeast part of the county north

of Woodland Junction. A low, broad ridge of sandy loam that probably represents the southern shore line of the old lake extends east and west thru Onarga. Another area is found below the Marseilles moraine in the northwest part of the county. This type is very irregularly distributed, being mixed with the brown silt loam, into which it grades. It covers altogether an area of 106.37 square miles, or about 9.5 percent of the area of the county. Its formation is due either to overflow by glacial drainage or to the action of the wind in carrying the sand from the overflow regions to the higher ones. It varies in topography from slightly rolling to flat.

The surface soil, 0 to 6⅔ inches, is a brown sandy loam varying in color from a light brown to a black and in physical composition from a loam with about 50 percent of sand to a very sandy loam carrying 75 percent, or slightly more, of sand. Many small areas of sand are found in this type but they are too small to be shown separately on the map. A representative sample would contain from 60 to 65 percent of sand, mostly of medium grade. The organic-matter content varies from 4.5 to 5.2 percent with an average of 5 percent, or 50 tons per acre.

The natural subsurface stratum varies in thickness from 7 to 12 inches, and in color from dark brown to brownish yellow, usually passing into a yellow sandy silt or silty sand in the lower part of the stratum. In physical composition it varies even more than the surface layer. The organic-matter content of the stratum sampled (6⅔ to 20 inches) is about 2 percent, or 40 tons per acre in four million pounds.

The subsoil varies both in color and in physical composition. The color may be a bright yellow under conditions of good drainage, or a drabbish yellow where the water table has been rather high. In composition, it may be sand, silt, or clayey silt. As a general rule, the subsoil of the poorly drained areas is heavier than that of the higher and more rolling parts. In some cases the subsoil of the more rolling land may be formed from boulder clay.

Management.—This type in many places needs drainage and, because of the pervious character of the subsoil, this is easily accomplished by tiling. For a sandy loam, the soil is reasonably well supplied with all elements of plant food. Where carbonates are absent, limestone should be used liberally; applications of 2 to 3 tons per acre should be made. A rotation including legumes should be practiced and organic residues should be returned to the soil. Where this is done, sufficient phosphorus and potassium are likely to be liberated for satisfactory results for many years to come, altho ultimately one or both of these elements may need to be supplied—phosphorus first on the more compact phase, and potassium first on the more sandy areas.

Alkali patches occur in considerable numbers, especially on the lower areas which contain the highest percentage of organic matter. The growth of sweet clover is recommended for these areas. One to two hundred pounds per acre of potassium salts may be applied on these alkali spots with good results.

Dune Sand (1081, 1181)

The upland dune sand covers an area of 2,976 acres. Its origin is due almost entirely to the blowing of sand from lower, sandy areas to the upland. The type

occurs principally in a few isolated areas where sandy loam prevails. In topography it varies from flat to rolling with many rounding elevations 20 to 40 feet high.

The surface soil, 0 to 6⅔ inches, varies from a yellow sand to a brownish yellow loamy sand, composed largely of material of medium grade. The soil is low in organic matter, having an average of only about 1.2 percent, or 12 tons per acre in the plowed soil.

The subsurface consists of yellow sand, with about .6 percent of organic matter.

The subsoil is much the same as the subsurface except that its organic-matter content is slightly lower.

Management.—The upland sand dunes should be treated in the same way as those of the terrace (see page 22). These dunes have usually been covered with scattering oak trees, chiefly *Quercus marylandica.*

Brown-Gray Silt Loam on Tight Clay (1128)

Brown-gray silt loam on tight clay occurs almost entirely in Townships 27 and 28 North, Ranges 13 and 14 West. None is found east of the Iroquois river, at least not in areas sufficiently large to be shown on the map. This type is flat in topography, having been formed by deposition from the waters of a shallow lake. A considerable degree of acidity has developed, and this may have aided in the formation of this peculiar type. The area covered by this type is 851 acres.

The surface soil, 0 to 6⅔ inches, is a brown silt loam, but it develops a grayish tint when it becomes dry after a rain. The color of the surface, however, is not uniform; there may be patches of different shades of gray mixed in with the darker soil, giving it a mottled appearance somewhat similar to the scalds of southern Illinois. The organic-matter content is about 3.8 percent, or 38 tons per acre.

The natural subsurface consists of a layer from 7 to 10 inches in thickness which varies from a brown silt loam to a grayish silt or a clayey silt. The upper part of the subsurface is about the same color as the surface soil, or it may be lighter. This is underlain by a grayish stratum varying from 2 to 8 inches in thickness, which is followed by a heavy subsoil.

The subsoil stratum is a heavy, plastic, impervious, yellowish clay that extends to a depth of several feet. It is sometimes underlain by a stratum of sand, but this is so deep that it has little or no effect on drainage.

Management.—Altho this type needs drainage very badly, it is difficult to drain because of the level topography and the impervious subsoil. According to the samples analyzed it is also acid and will require limestone to correct the acidity and to put it into condition for growing clovers to the best advantage. About 2 to 4 tons of limestone per acre is recommended. The phosphorus content is about the same as that of the brown silt loam, and for permanent improvement this element should be supplied. In the management of this soil one very important consideration is the increasing of the organic-matter content. To do this, all forms of crop residues should be turned under, as well as legume crops. Deep-rooting crops should be grown to open up the subsoil.

Brown Silt Loam on Tight Clay (1128.1)

Brown silt loam on tight clay occurs in the same region as brown-gray silt loam on tight clay, but is a slightly better soil because of the absence of the gray stratum in the subsurface and the presence of a more pervious subsoil. This type covers an area of 4,710 acres.

The surface soil, 0 to 6⅔ inches, is a brown silt loam which shows a grayish tint after becoming dry. The color, however, is not uniform, being lighter in some parts than in others. This gives a field the same mottled appearance that is seen in the preceding type. The stratum contains about 4 percent of organic matter, or 40 tons per acre.

The subsurface consists of a brown silt loam which passes into a heavy brownish clayey material at 12 to 15 inches in depth. The stratum sampled (6⅔ to 20 inches) has about 2 percent of organic matter, or 40 tons per acre.

The subsoil consists of a yellowish or drabbish yellow clay, very plastic and tough. It is rather impervious, with the result that drainage does not take place very readily.

Management.—Because the type is usually lacking in limestone in the upper strata, an application of 2 tons per acre of this material is recommended. Drainage is very difficult because of the tight subsoil, and in order to drain it well the lines of tile must necessarily be placed much closer than in the brown silt loam (1126). The requirement as to organic matter is the same as for the preceding type. Deep-rooting crops such as sweet clover will be of great benefit.

(b) UPLAND TIMBER SOILS

The upland timber soils include nearly all the upland areas that are now, or have been, covered with forests. These soils contain much less organic matter than those of the prairie because of the difference in the vegetation that covered them. In forests the vegetable material from trees accumulates upon the surface and is either burned or suffers almost complete decay. Grasses, which furnish large amounts of humus-forming roots, do not grow to any extent because of the shade. Moreover, the organic matter that had accumulated before the timber began growing is removed thru various decomposition processes, with the result that in these soils generally the content of nitrogen and organic-matter has become too low for the best growth of farm crops.

The total area of upland timber soils in the county is 24.40 square miles, or 2.17 percent of the area of the county.

Yellow-Gray Silt Loam (934, 1034, 1134, 1234)

Yellow-gray silt loam is not very extensive in this county, altho it is distributed along most of the courses of the larger streams, where it forms a narrow belt on either side. The area covered by this type is 16.74 square miles, or about 10,000 acres. In topography, it is undulating to slightly rolling and usually has good surface drainage.

The surface soil, 0 to 6⅔ inches, is a gray or yellowish gray silt loam, incoherent and mealy but not granular. In physical composition it varies according to its relation to other types. Where it occurs in the sandy loam areas it

frequently becomes somewhat sandy, and very small areas may contain enough sand to be mapped as sandy loam. White oak and hickory are common trees on this type. The organic-matter content is about 2.1 percent, or 21 tons per acre. The amount increases where the type grades into the brown silt loam which usually borders it.

The natural subsurface stratum varies from 3 to 10 inches in thickness. In color it is gray, grayish yellow, or yellow. It is somewhat pulverulent, but becomes more coherent and plastic with increasing depth. The amount of organic matter of the stratum sampled (6⅔ to 20 inches) is about .7 percent.

The subsoil is a yellow or grayish yellow clayey silt or silty clay, somewhat plastic when wet but pervious to water. Sometimes the subsoil is made up wholly or in part of glacial material. The type as mapped includes some narrow, steep slopes along the bottom lands of streams, that are really yellow silt loam but are too narrow to be shown as such on the map.

Management.—In the management of yellow-gray silt loam, one of the most essential considerations is the maintenance or increase of organic matter. This is much more necessary with the yellow-gray silt loam than with the brown silt loam because of the fact that this soil is naturally much lower in organic matter, having only about two-fifths as much as the brown silt loam. The deficiency of organic matter causes the soil to run together, in the freezing and thawing of winter and in the wetting by the heavy rains of spring and summer. Organic matter will help to prevent washing on the more rolling areas. As it decays, it supplies nitrogen and at the same time tends to liberate other plant-food elements, as explained in the Appendix.

Since the soil is sometimes acid, it is often necessary to apply 2 or 3 tons per acre of ground limestone before the best results can be obtained with legumes. Later applications may be smaller. The growth of legumes is very essential since they furnish organic matter to turn back into the soil and at the same time supply the necessary nitrogen. But all forms of organic matter, such as corn stalks, manure, and weeds are of value and they should be turned into the soil rather than burned. An application of about ½ to 1 ton of rock phosphate per acre should be made about every four years, preferably when the legume or manure is turned under or else preceding the sowing of clover. For the results of field experiments on this type of soil the reader is referred to page 55 of the Supplement.

Yellow-Gray Sandy Loam (1164, 1264)

With only a few exceptions, the yellow-gray sandy loam occurs adjacent to the streams in a manner similar to the yellow-gray silt loam. The type is usually slightly rolling. It covers an area of 2,867 acres.

The surface soil, 0 to 6⅔ inches, is a gray to yellow-gray sandy loam containing about .75 percent of organic matter, or 7.5 tons per acre.

The subsurface is a sandy loam varying in color from yellow to grayish yellow. It contains almost as much organic matter as the surface soil.

The subsoil varies considerably, being made up in some places of a yellowish, sandy, clayey material, while in others it is composed of boulder clay, and in still others, of sand.

Management.—As a type, the yellow-gray sandy loam is somewhat inferior to most other soils of the county. It is low in practically all elements of fertility. In the samples examined carbonates were lacking even in the subsoil. Where such a condition exists 2 to 4 tons of limestone per acre should be applied so that legumes will grow well. The legumes should be turned under to increase the amount of nitrogen which is now much too low for a productive soil. All organic residues should be put back into the soil for the same purpose. The type is low in phosphorus, and ultimately this element must be supplied if the best results are to be obtained in the growth of crops. This element can be built up by the application of about ½ to 1 ton per acre of rock phosphate once in the rotation for two or three rotations, and thereafter a quantity sufficient to replace what is removed by crops.

Yellow Silt Loam (1135)

Yellow silt loam is found on steep slopes along the streams, and its origin is due to erosion. It covers an area of 1,011 acres.

The surface soil, 0 to 6⅔ inches, consists of a yellow to brownish yellow silt loam varying in composition from a sandy material on the one hand to a rather heavy phase on the other. The surface stratum contains about 2.4 percent of organic matter, or 24 tons per acre.

The subsurface is a yellow silty or sandy material varying toward a silty clay. The stratum contains about one percent of organic matter.

The subsoil is a yellow clayey silt and in many cases is formed from boulder clay.

The type is usually not under cultivation and can be used only for pasture.

Yellow-Gray Silt Loam on Tight Clay (1138)

Yellow-gray silt loam on tight clay occurs only in Township 27 North, Range 13 West. It covers only 1,024 acres.

The surface soil, 0 to 6⅔ inches, is a gray or yellowish gray silt loam containing about 2.9 percent of organic matter, or 29 tons per acre.

The subsurface is a grayish yellow silt loam passing into a heavy impervious stratum at about 15 to 17 inches. It contains 1.3 percent of organic matter or 26 tons per acre in four million pounds of soil.

The subsoil is a stiff, impervious clay, varying from yellow to drabbish yellow in color.

Management.—The greatest needs of this type are limestone and legume crops. The subsurface is usually quite acid, altho the subsoil in some places contains a small amount of limestone. Fortunately this very poor type of soil covers but a small area.

(c) TERRACE SOILS

The terrace soils of Iroquois county are formed in two ways: first, as gravel outwash plains from the melting glacier; and second, as gravel fills in stream valleys. The extensive areas along Beaver creek and in the vicinity of Pittwood, also south and east of Crescent, are of the former formation while those along

Sugar creek and the Iroquois river are of the latter. The depth to the gravel and sand varies to some extent, being from 24 inches to five feet or more. On account of the high water table resulting from the shallow cuts of streams the terrace types in this county are not easily drained.

The total area of all the terrace types in Iroquois county is 167.49 square miles, or nearly 15 percent of the area of the county.

Brown Sandy Loam (1560)

The brown sandy loam of the terrace, is one of the most common types in Iroquois county. It covers 108.30 square miles, or nearly 10 percent of the area of the county. It does not differ very much in composition from the upland sandy loam.

The surface soil, 0 to 6⅔ inches, is a brown sandy loam varying in color from black to light brown, and in composition from a loam to a sand. A representative sample, however, will contain about 65 to 70 percent of sand. The organic-matter content varies from 3 to 8 percent, with an average of about 5.1 percent, which is equivalent to 51 tons per acre.

The natural subsurface consists of a sandy loam layer varying in thickness from 6 to 12 inches and in color from black to brownish or yellowish. The organic-matter content of the stratum sampled (6⅔ to 20 inches) is about 1.7 percent, or 34 tons per acre.

The subsoil is a yellow to drabbish yellow clayey sand varying to a sandy clay, and is readily pervious to both air and water. Limestone is sometimes found in the subsoil.

Management.—The analysis of samples taken from different locations show great variation with respect to the limestone requirement. In some localities carbonates are abundant in all strata analysed, while in other places these are absent in all strata. In this situation, therefore, it is especially necessary to apply the tests for acidity and carbonates described on page 37 of the Appendix. If carbonates are not present within a foot of the surface, this fact may be taken as a sure indication that limestone is needed for the thrifty growth of legumes; it should be applied at the rate of 2 to 4 tons per acre. Phosphorus fertilizer is not so necessary on this kind of soil as on the brown silt loam, owing to the fact that on this type the roots of plants are distributed to a greater extent thru the soil and to a greater depth than in the brown silt loam. However, this element is becoming somewhat low and in some instances applications may be profitable, especially after the stock of nitrogen is well built up.

Brown Silt Loam (1526)

Brown silt loam occurs as rather isolated areas in the terraces and covers only 2.66 square miles, or 1,702 acres.

The surface soil, 0 to 6⅔ inches, contains approximately the same percentage of organic matter as the upland brown silt loam. In physical composition it varies to a considerable extent according to the surrounding soil types, and often grades into a sandy loam.

The natural subsurface is represented by a stratum 7 to 11 inches in thickness. It is a brown silt loam which changes to yellow with increasing depth.

The subsoil is a yellow sandy silt or sandy clay varying to a yellow sand. It is easily permeated by water and air.

Management.—The type requires the same treatment as the upland brown silt loam (see page 10).

Brown Silt Loam over Gravel (1527)

Brown silt loam over gravel is found principally along the streams and constitutes a part of the true stream terrace. It covers an area of 13.20 square miles, or 8,448 acres.

The surface soil, 0 to 6⅔ inches, is a little lighter in color than the upland brown silt loam. It varies somewhat in composition, being distinctly sandy in some places. It contains about 4.4 percent of organic matter, or 44 tons per acre.

The natural subsurface comprizes a silt loam stratum varying from 6 to 12 inches in thickness. It varies in color from brown to light brown. The stratum sampled (6⅔ to 20 inches) contains about 2.1 percent of organic matter, or 42 tons per acre.

The subsoil varies from a yellow silt to a yellow sandy silt. In some instances gravel is found at a depth of 36 to 48 inches. This provides good drainage where the water table is lowered sufficiently.

Management.—In the samples examined the lower strata of this type were acid. In cases where this is the condition, 2 or 3 tons of limestone per acre will be required as an initial application to correct the acidity and thus provide favorable conditions for the growth of legumes. About half the amount of this initial application should be applied every four years thereafter, or until the most favorable conditions for the growth of legumes are established. The same need for turning under legumes and organic residues exists in this type as in other brown silt loam types of the county.

Yellow-Gray Sandy Loam (1564)

Yellow-gray sandy loam is found very largely along the streams, altho an occasional small area may form an exception to this. It is associated with the yellow-gray silt loam in that it occurs in similar situations and that it has been covered by forests. The total area occupied by this type is 5,850 acres.

The surface soil, 0 to 6⅔ inches, is a brownish gray or brownish yellow sandy loam varying in physical composition in the same way as the other sandy loams of the county. The organic-matter content is about 2.5 percent, or 25 tons per acre.

The subsurface is a yellow sandy loam varying to a sandy silt loam and even to a sand. It contains about .5 percent of organic matter.

The subsoil consists of a yellow sandy silt that extends into gravel, in some instances at a depth of 36 to 40 inches. It contains about .45 percent of organic matter.

Management.—According to the samples tested this type is strongly acid, and an initial application of about 4 tons of limestone per acre should be made. This should be followed with about 2 tons every four years until the soil is brought into condition for the best growth of legumes. Organic matter, especially

legumes, must be turned under to bring about conditions of good tilth in the soil and to increase the supply of nitrogen, which analysis shows to be extremely low. The phosphorus content is likewise extremely low and ought to be built up before it becomes a limiting element.

Dune Sand (1581)

Dune sand on the terrace consists of rather small, irregular, isolated areas, all of them together covering 18.5 square miles, or 1.65 percent of the area of the county. These dunes have been formed of sand deposited as sand bars by the streams that once covered these regions. Later this sand was reworked by the wind, which piled it up into dunes ranging from a few feet to 25 or 30 feet in height.

The surface soil, 0 to 6⅔ inches, varies from a brownish yellow, slightly loamy sand to a yellow sand. It contains about 1.2 percent of organic matter, or 12 tons per acre. The sand is usually of medium texture and is comparatively free from the finer constituents.

The subsurface consists of a layer composed very largely of yellow sand, altho on the more loamy phases there may be enough organic matter to give the top of this stratum a brownish tint. It contains about .6 percent of organic matter.

The subsoil is a yellow sand with about .4 percent of organic matter.

Management.—This dune sand contains no limestone, either in the surface, subsurface, or subsoil, and it is exceedingly poor in nitrogen. Altho the total supply of potassium is large, this element is likely to be locked up to a considerable extent in sand grains and consequently is not susceptible of liberation by practical means altho sufficient amounts can usually be made available for very good crops. (On swamp sands and sandy loams long exposed to leaching, potassium is often the first limiting element, especially where a fair supply of humus exists, as in the so-called "black sand.")

The phosphorus content of sand soils is not high, but this element exists to a considerable extent in other constituents than sand grains. The United States Bureau of Soils separated two types of sandy soil—glacial sand and sandy loam—into coarse, medium, and fine particles, analyzed each grade for phosphorus, and found that as an average of the two soils the fine portion was eighteen times as rich in the element phosphorus as the coarse. Under successful cropping, such a limited amount of phosphorus as this dune sand contains would, however, sooner or later become exhausted, altho field experiments might not indicate a need for this element at first.

In the management of this type, the two things of first and by far the greatest importance are the addition of limestone and of organic matter. While this sand soil is not high in acidity, the samples examined were entirely devoid of limestone to a depth of more than 40 inches. For satisfactory results, therefore, an initial application of 3 to 4 tons per acre should be made, and this supply should be maintained by subsequent applications of about 2 tons every four or five years, or until conditions are established for the best growth of legumes.

Organic matter is needed to increase the moisture-retaining power, to furnish nitrogen, and to prevent blowing. Sand possesses very little cohesion, and is therefore readily moved by the wind. In fact, wind erosion on this soil is worse than water erosion on other soils, and unless some special means are used, especially on the more sandy areas, to prevent the movement by wind action, ultimate ruin of the soil will result. When organic matter is added, it acts as a feeble cement which, however, is sufficiently strong to bind the soil particles together and prevent blowing. In a test at this Station, the moisture-holding capacity of clean medium sand was increased 40 percent by the addition of 5 percent of peat, and 85.7 percent by the addition of 10 percent of peat.

When potash salts can be secured at reasonable cost, their use is likely to produce profitable results, at least temporarily, in getting under way systems of permanent improvement on this soil. This applies more especially to the level areas which were originally sandy swamps.

Corn on sand land "fires" very badly; that is, the lower leaves dry up. This is partly due to the fact that the soil is low in the element nitrogen and there is a translocation of the nitrogen from the lower to the upper leaves in order to continue growth. This drying up, which is usually attributed to lack of moisture, can be largely prevented by the presence of plenty of available nitrogen. The fact should be remembered that less moisture is required to produce a crop on a soil plentifully supplied with plant food than to produce one on a poor soil.

Rye is one of the hardy non-legumes often grown on sand soil, but this crop does not sufficiently cover the soil to protect it from blowing. Furthermore, it is a common practice to sell the straw as well as the grain, and this leaves very little organic matter to be turned back into the soil. A practice that could be followed to good advantage in favorable seasons would be to sow cowpeas after the rye, following the binder with the drill, and then later drilling rye in the cowpeas without cutting them or turning them under. This would serve to protect the soil from blowing as well as to furnish a supply of nitrogen and organic matter, and the practice would undoubtedly result in the improvement of this loose sandy type.

Cowpeas are well adapted to such soil, and they produce very large yields of excellent hay or grain very valuable for feed and seed. Under the best conditions and with good preparation, sweet clover can be grown in good seasons with proper soil treatment. With an abundance of limestone and moderate manuring, alfalfa can also be grown. More than five tons of alfalfa hay per acre in one year has been produced on an experiment field at Green Valley and similar results have been obtained on the Oquawka field. Sweet clover and alfalfa should be inoculated with the proper nitrogen-fixing bacteria.

Other possibilities of this type of soil may be shown by the use to which it is put in the vicinity of Wichert, where truck farming is carried on extensively. Where heavily manured, this dune sand has become very valuable for growing asparagus and other crops.

Foresting is a practical way of conserving these sand soils. The black locust (a leguminous tree) seems to do exceptionally well on sand. One difficulty with this tree, however, is that it is damaged by borers; but if it is used to start a

growth and hold the sand, other trees may then be interplanted and the result will be that the sand will be held permanently. After the blowing of sand is once stopped, very careful treatment is required to prevent a recurrence of the trouble. Pasturing should be done very carefully, because the grass is easily destroyed.

For an account of field experiments on dune sand see page 58 of the Supplement.

Yellow-Gray Silt Loam (1534)

Yellow-gray silt loam occurs in small areas along streams, particularly along the Iroquois river. It is very little different from the following type, yellow-gray silt loam over gravel, except that it appears to be of a later formation and the gravel does not occur.

The surface soil, 0 to 6⅔ inches, is a yellowish gray or yellowish brown silt loam with an organic-matter content of about 2.9 percent, or 29 tons per acre.

The subsurface is a yellowish or brownish yellow silt loam.

The subsoil is a yellow silt, in some places becoming rather heavy while in other places it is friable.

Management.—The treatment of this type should be the same as that of the yellow-gray silt loam over gravel (1536).

Yellow-Gray Silt Loam over Gravel (1536)

Yellow-gray silt loam over gravel occurs principally along the Iroquois river and Sugar creek, and is usually 25 to 30 feet above the bottom land. It covers an area of 6.37 square miles, or 4,077 acres.

The surface soil, 0 to 6⅔ inches, is a yellowish or grayish yellow silt loam, varying in sand content to a loam and in some places even to a sandy loam. The organic-matter content ranges from 1.8 to 3 percent, and averages 2.4 percent, or 24 tons per acre.

The subsurface is a yellow silt loam containing .8 percent of organic matter, or about 16 tons per acre.

The subsoil is a yellow silty material underlain by gravel, which in some places is less than 40 inches beneath the surface. It contains about .4 percent of organic matter.

Management.—In the management of this type, one of the first requirements is an application of 2 to 3 tons of limestone per acre to correct the acidity which in the subsoil becomes very high. The low content of organic matter indicates that it would be desirable to turn under all residues possible. Legumes should be grown and the best use made of straw, residues, and manure. Along with the improvement in this way, it would be of benefit to apply from ½ to 1 ton of rock phosphate per acre once in the rotation until the phosphorus content is well built up in the soil. This would be a good soil for alfalfa, as it is generally well drained, owing to the underlying stratum of gravel.

Brown Sandy Loam over Gravel (1566)

Brown sandy loam over gravel occurs along the Iroquois river and Sugar creek, and is formed in the same way as the preceding type (1536). It includes a total area of 3,187 acres.

The surface soil, 0 to 6⅔ inches, is a brown sandy loam varying on the one hand to brown silt loam, and on the other to sand. It contains about 2.9 percent of organic matter, or 29 tons per acre.

The subsurface is a brown sandy loam, passing into a yellowish sandy silt at a depth of about 15 inches. It contains about 1.6 percent of organic matter.

The subsoil is a yellow sandy silt varying to a silt. The gravel is sometimes found at a depth of less than 40 inches altho it usually occurs at greater depths.

Management.—In the samples examined the subsurface and subsoil strata were acid. Where this condition occurs it will be necessary to apply 2 or 3 tons of limestone per acre to secure the best results with legumes. The same use must be made of organic residues and manure as that indicated for the preceding type. Applications of phosphorus will aid in giving satisfactory results, both for legumes and for grain crops.

Yellow-Gray Sandy Loam over Gravel (1567)

Yellow-gray sandy loam over gravel occurs along the streams in a manner similar to that of the preceding type, but it has been timbered sufficiently long to reduce the organic matter to a very small amount. It covers an area of 3.30 square miles, or 2,112 acres.

The surface soil, 0 to 6⅔ inches, is a gray to light yellow sandy loam. It ranges in texture from a loam to a very sandy phase of sandy loam. It contains about 1.8 percent of organic matter, or 18 tons per acre.

The subsurface soil is a gray or yellowish gray sandy loam, passing into the heavier phase characteristic of the subsoil at a depth of about 15 to 17 inches.

The subsoil consists usually of a sandy clayey material that is underlain by gravel at a depth of 36 to 54 inches.

Management.—This type is very low in nitrogen, containing only 1,420 pounds per acre in the plowed soil. Legumes must be grown in order to increase the nitrogen content. Since the soil is very acid, it is necessary to apply 3 to 4 tons of limestone per acre to produce the best growth of legumes. All available organic residues and farmyard manure must be turned under in order to increase and maintain the supply of organic matter and nitrogen. This soil is also very low in phosphorus, and this element should be added.

Brown Silt Loam on Gravel (1526.4)

Brown silt loam on gravel occurs to a limited extent along Sugar creek in the vicinity of Woodland Junction. It covers only 211 acres.

The surface soil, 0 to 6⅔ inches, is lighter in color than the upland brown silt loam. It contains about 3 percent of organic matter.

The subsurface soil is a yellowish brown or brownish yellow silt loam.

The subsoil is a yellow sandy or gravelly silt loam passing into gravel at a depth of about 26 to 32 inches.

Management.—This type requires the same treatment as brown silt loam over gravel (1527) (see page 21). The gravel subsoil gives good drainage.

Black Clay Loam (1520)

Black clay loam of the terrace does not differ much from the upland black clay loam; hence the treatment that it should receive is practically the same. The reader is therefore referred to the discussion of black clay loam on page 13.

(d) SWAMP AND BOTTOM-LAND SOILS

This group includes the bottom lands along the streams, the swamps, and the poorly drained lowlands. Much of the soil, therefore, is of alluvial formation and the land is largely subject to overflow. The swamps were formerly what their name implies, but during the wettest part of the year at least they were shallow ponds or lakes. Seven types of this group are recognized in Iroquois county, the total area of which aggregates 48.76 square miles, or about 4.5 percent of the area of the county.

Deep Brown Silt Loam (1426)

Deep brown silt loam constitutes the larger part of the bottom land along the streams. Altho it varies slightly in some places, especially toward the northern part of the county, yet generally it consists of a brown silt loam, the dark color of which extends to a depth of 20 to 30 inches. It covers an area of 29.06 square miles, or 2.59 percent of the area of the county. At one time the terrace constituted the overflow land of the streams of the county, but later the streams cut below this terrace and began to develop a new flood plain that is the present first bottom land.

The surface soil, 0 to 6⅔ inches, is a brown silt loam containing from 5 to 7 percent of organic matter, or an average of 6 percent. The surface soil varies somewhat, owing to the deposition of sand in times of overflow.

The subsurface soil, 6⅔ to 20 inches, consists of a brown silt loam containing more or less sand. The organic-matter content is about 5.1 percent.

The subsoil varies from a brown silt loam to a yellowish or brownish yellow silt loam, and contains about 2.4 percent of organic matter.

Management.—This type contains a good supply of organic matter and nitrogen and has a phosphorus content varying from 1,200 to 1,600 pounds per acre in the plowed soil. The soil is usually either neutral or slightly acid, altho not so acid but that legumes will do well upon it. During times of overflow the type receives a deposit of rich soil. Therefore the most important requirement in its management is good cultivation. Large numbers of weed seed are deposited during flood times, and these are frequently a source of much trouble.

Mixed Loam (1454)

Mixed loam occurs principally as bottom land along Beaver creek in the northeastern part of the county. So much sand is carried into this stream that the bottom-land soil is badly mixed and it is therefore practically impossible to separate it into distinct types. Even if this could be done, the next flood would probably change the character of the soil. The area covered by this type amounts to 2,483 acres.

The surface soil, 0 to 6⅔ inches, is a mixed loam varying from a sand to a silt loam. It contains about 6.6 percent of organic matter.

The subsurface soil, 6⅔ to 20 inches, is a brown mixed loam with about 1.43 percent of organic matter.

The subsoil varies in somewhat the same way as the surface and is usually of a yellowish or brownish yellow color.

The type is of little importance so far as agriculture is concerned. It is used mainly for pasture.

Black Sandy Loam (1461)

Black sandy loam occurs in several isolated areas, the largest being in the northwest part of the county just south of the Marseilles moraine. This type covers an area of 12.61 square miles.

The surface soil, 0 to 6⅔ inches, is a black sandy loam varying on the one hand to a clayey sandy loam and on the other to a peaty loam. It contains about 5.3 percent of organic matter, or 53 tons per acre.

The natural subsurface consists of a stratum 8 to 12 inches thick, and varies from a brown to a yellowish brown sandy loam. This stratum usually contains sufficient amounts of the finer constituents, either clay or fine silt, to give it some tenacity. The organic-matter content of the stratum sampled is about 1.6 percent, or 32 tons per acre.

The subsoil consists of a pale yellow to grayish colored sandy clay or clayey sand and contains about .5 percent of organic matter.

Management.—The type needs drainage first, and while most areas have been drained, yet in some localities much more is needed. An occasional legume crop is desirable to aid in keeping the soil in good physical condition and in maintaining the nitrogen content. Where carbonates are absent, limestone should be applied in order to provide the most favorable conditions for the growth of legumes.

Peaty Loam on Sand (1410.2)

Peaty loam on sand covers only a small area, amounting to 288 acres.

The surface soil is a peaty loam consisting of organic matter and sand. The organic-matter content is about 19.8 percent, or 148.5 tons per acre.

The subsurface contains a little more than half the amount of organic matter that is found in the surface.

The subsoil is a gray or drab sand with only .8 percent of organic matter.

Management.—Proper drainage is of course essential in the successful cultivation of this kind of soil. Experience on soil of a similar nature has shown good returns from the use of manure and of potassium sulfate.

Deep Peat (1401)

Deep peat is found in small areas on both upland and terraces and covers 1,139 acres, or .16 percent of the area of the county. The soil to a depth of at least 30 inches consists largely of organic matter derived from mosses, sedges, and grasses.

The surface soil, 0 to 6⅔ inches, consists of a black or brownish peat, more or less decomposed. As a general rule, the drained areas have undergone greater decomposition because of better aeration, while the undrained areas have changed but little. The content of organic matter is about 59 percent, or 295 tons per acre.

The subsurface soil, 6⅔ to 20 inches, is a black or brownish peat that usually shows the texture of the material from which it was produced. The organic-matter content is about 31 percent.

The subsoil, 20 to 40 inches, is usually a brown peat, altho in small areas, sand, silt, or clay of a drab color may constitute the subsoil below 30 inches. The organic-matter content varies widely. The line between the peat and the mineral subsoil is usually very distinct.

Management.—Because of lack of drainage, this type of soil in Iroquois county has not been cultivated to a large extent. It is used mostly for pasture, and probably this is the best use to which it can be put. Tile drainage is not usually satisfactory because the soft peat soon permits the tile to get out of line and this seriously interferes with drainage.

Where thoro drainage can be provided either by open ditches or by laying tiles deep enough to secure a solid bed for them, very marked improvement can be made in the productive power of deep peat by the liberal use of potassium, which is by far the most deficient element. These soils frequently contain alkali that irritates the skin. The term "itch dirt" is often applied to them.

In the Supplement to this report are given the results obtained from field experiments on deep peat (see page 60).

Medium Peat on Clay (1402)

Medium peat on clay consists of a soil in which the peat is more than 12 and less than 30 inches in depth. Typically it is underlain by clay or silty clay, altho in some locations sand may occur instead of clay. This soil originates in the same way as deep peat. The total area in the county is 467 acres.

The surface soil, 0 to 6⅔ inches, is a brown or black peat, which may contain some sand. If the sand content becomes very high, the type passes into the peaty loam, a small area of which borders it on the south. The organic-matter content is about 36 percent.

The subsurface varies widely even in the same locality. The organic matter or peat may form a part of the subsurface or the entire stratum. The organic-matter content is approximately 9.8 percent.

The subsoil may be formed in part of peat. The mineral part consists of clay and sand but is distributed so irregularly that it is impossible to separate the areas into the two types. The clay subsoil seems to be the more prevalent. The organic-matter content is about 2.6 percent.

Management.—Drainage is one of the principal considerations in the management of the type. It may usually be provided without much difficulty because the clay affords a good bed for tile. The treatment for this type is likely to be the same as for deep peat, but thoro trials should be made with potassium in

advance of extensive use, for the surface and subsurface strata sometimes have sufficient potassium contained in the mineral particles deposited from repeated overflow.

Clayey Muck (1413)

Clayey muck is found in the northwestern part of the county in a few areas just south of the morainal ridge. These areas cover 160 acres.

The surface soil consists of a black, granular, plastic, clayey material having about 17.5 percent of organic matter.

The subsurface is very similar to the surface except that in its lower depths its assumes a slightly more drabbish color. It contains about 19 percent of organic matter.

The subsoil usually consists of a black to drabbish clay, waxy, but pervious to water. The sample collected contained about 10 percent of organic matter.

Management.—The upper strata of this soil contain no limestone but carbonates are found in the subsoil. Drainage is the first requirement, and after that good cultivation is about all that is necessary. The supply of potassium is abundant, as is also that of phosphorus, clayey muck being one of the richest soils of the county in this constituent. The rotation of crops is necessary in order to control insects and weeds.

APPENDIX

EXPLANATIONS FOR INTERPRETING THE SOIL SURVEY

CLASSIFICATION OF SOILS

In order to intelligently interpret the soil maps, the reader must understand something of the method of soil classification upon which the survey is based. Without going far into details the following paragraphs are intended to furnish a brief explanation of the general plan of classification here used.

The unit in the soil survey is the soil type, and each type possesses more or less definite characteristics. The line of separation between adjoining types is usually distinct, altho sometimes one type grades into another so gradually that it is very difficult to draw the line between them. In such exceptional cases, some slight variation in the location of soil-type boundaries is unavoidable.

In establishing soil types several factors must be taken into account. These are: (1) the geological origin of the soil, whether residual, cumulose, glacial, eolial, alluvial, or colluvial; (2) the topography, or lay of the land; (3) the native vegetation, as forest or prairie grasses; (4) the depth and the character of the surface, the subsurface, and the subsoil, as to the percentages of gravel, sand, silt, clay, and organic matter which they contain, their porosity, granulation, friability, plasticity, color, etc.; (5) the natural drainage; (6) the agricultural value, based upon its natural productiveness; (7) the ultimate chemical composition and reaction.

Great Soil Areas in Illinois.—On the basis of the first of the above mentioned factors, namely, the geological origin, the state of Illinois has been divided into sixteen great soil areas with respect to their geological formation. The names of these areas are given in the following list along with their corresponding index numbers, the use of which is explained below. For the location of these geological areas, the reader is referred to the general map published in Bulletins 123 and 193.

100 *Unglaciated,* comprizing three areas, the largest being in the south end of the state
200 *Illinoisan moraines,* including the moraines of the Illinoisan glaciation
300 *Lower Illinoisan glaciation,* covering nearly the south third of the state
400 *Middle Illinoisan glaciation,* covering about a dozen counties in the west-central part of the state
500 *Upper Illinoisan glaciation,* covering about fourteen counties northwest of the middle Illinoisan glaciation
600 *Pre-Iowan glaciation,* but now believed to be part of the upper Illinoisan
700 *Iowan glaciation,* lying in the central northern end of the state
800 *Deep loess areas,* including a zone a few miles wide along the Wabash, Illinois, and Mississippi rivers
900 *Early Wisconsin moraines,* including the moraines of the early Wisconsin glaciation
1000 *Late Wisconsin moraines,* including the moraines of the late Wisconsin glaciation
1100 *Early Wisconsin glaciation,* covering the greater part of the northeast quarter of the state
1200 *Late Wisconsin glaciation,* lying in the northeast corner of the state
1300 *Old river bottom and swamp lands,* found in the older or Illinoisan glaciation
1400 *Late river bottom and swamp lands,* those of the Wisconsin and Iowan glaciations
1500 *Terraces,* formed by overloaded streams draining from the glaciers and gravel outwash plains
1600 *Lacustrine deposits,* formed by Lake Chicago or the enlarged Lake Michigan

Mechanical Composition of Soils.—The mechanical composition, or the texture, is a most important feature in characterizing a soil. The texture depends upon the relative proportions of the following physical constituents:

Organic matter: undecomposed and partially decayed vegetable material

Inorganic matter: clay, silt, fine sand, sand, gravel, stones.

Classes of Soils.—Based upon the relative proportion of the various constituents mentioned above, soils may be grouped into a number of well recognized classes. Following is a list of these classes, arranged according to their index numbers, the use of which is explained below.

Index Number Limits	Class Names
0 to 9	Peats
10 to 12	Peaty loams
13 to 14	Mucks
15 to 19	Clays
20 to 24	Clay loams
25 to 49	Silt loams
50 to 59	Loams
60 to 79	Sandy loams
80 to 89	Sands
90 to 94	Gravelly loams
95 to 97	Gravels
98	Stony loams
99	Rock outcrop

Naming and Numbering Soil Types.—The naming of soil types has been the subject of much discussion, and practice varies considerably in this matter. In this soil survey of Illinois a system of classification and naming has been adopted which is based upon the various considerations presented in the preceding paragraphs.

After texture, one of the most striking characteristics of a soil is the color. Therefore, in the naming of soils in Illinois, a combination of color and texture, together with other descriptive terms when necessary, has been adopted so that the name in itself carries a definite description of a given soil type; as for example, "gray silt loam on tight clay," or "brown silt loam over gravel." The use of the prepositions *on* and *over* serves to indicate the presence of certain substrata. When the surface soil is underlain with material such as sand, gravel, or rock, the word *over* is used if this material lies at a depth greater than 30 inches; if it is less than 30 inches, the word *on* is used.

For further identification of soil types a system of numbering, resembling somewhat the Dewey library system, has been adopted whereby each soil type is assigned a certain number. This number indicates at once the geological origin of the soil as well as its physical description. The digits of the order of hundreds represent the geological area where the soil is found, beginning at 100 with the unglaciated, and following in series in the order of the enumeration presented in the paragraph above headed *Great Soil Areas In Illinois.* The digits of the orders of units and tens represent the various kinds of soil such as are enumerated above in the list of soil classes. A modification of a soil type called a *phase* is designated in this system by a figure placed at the right of the decimal point. To illustrate the working of this numbering system, suppose a soil type bears the number 726.5. The number 7 indicates that this soil occurs in the Iowan glaciation, the 26 that it is a brown silt loam, and the .5 that rock is found less than 30 inches below the surface. These numbers are especially useful in designating small areas on the map and as a check in reading the colors.

A complete list of the soil types occurring in each county, along with their corresponding type numbers and a description of the area covered, will be found in the respective county soil reports.

SOIL SURVEY METHODS

Mapping the Soil Types.—In conducting the soil survey, the county constitutes the unit of working area. In order that the survey be thoroly truthworthy it is necessary that careful, well-trained men be employed to do the mapping. The work is prosecuted to the best advantage by working in parties of from two to four. Only such men are placed in charge of these parties as are thoroly experienced in the work and have shown themselves to be especially well qualified in training and ability.

The men must be able to keep their location exactly and to recognize the different soil types, with their principal variations and limits, and they must show these upon the maps correctly. A definite system is employed in checking up this work. As an illustration, one man will survey and map a strip 80 rods or 160 rods wide and any convenient length, while his associate will work independently on another strip adjoining this area, and if the work is correctly done the soil-type boundaries will match up on the line between the two strips.

An accurate base map for field use is absolutely necessary for soil mapping. The base maps are prepared on a scale of one inch to the mile, the official data of the original or subsequent land survey being used as a basis in their construction. Each surveyor is provided with one of these base maps, which he carries with him in the field; and the soil-type boundaries, together with the streams, roads, railroads, canals, and town sites are placed in their proper locations upon the map while the mapper is on the area. Each section, or square mile, is divided into 40-acre plots on the map, and the surveyor must inspect every ten acres and determine the type or types of soil composing it. The different types are indicated on the map by different colors, pencils for this purpose being carried in the field.

A small auger 40 inches long forms for each man an invaluable tool with which he can quickly secure samples of the different strata for inspection. An extension for making the auger 80 inches long is taken by each party, so that any peculiarity of the deeper subsoil layers may be studied. Each man carries a compass to aid in keeping directions. Distances along roads are measured by an odometer attached to the axle of the vehicle or by some other measuring device, while distances in the field away from the roads are determined by pacing, an art in which the men become expert by practice. The soil boundaries can thus be located with as high a degree of accuracy as can be indicated by pencil on the scale of one inch to the mile.

Sampling for Analysis.—After all the soil types of a county have been located and mapped, samples representative of the different types are collected for chemical analysis. For this purpose usually three strata are sampled; namely, the surface (0 to 6⅔ inches), the subsurface (6⅔ to 20 inches), and the subsoil (20 to 40 inches). These strata correspond approximately, in the common kinds of soil, to 2,000,000 pounds of dry soil per acre in the surface layer, and to two times and three times this quantity in the subsurface and the subsoil, respectively.

By this system of sampling we have represented separately three zones for plant feeding. The surface layer includes at least as much soil as is ordinarily turned with the plow. This is the part with which the farm manure, limestone, phosphate, or other fertilizer applied in soil improvement is incorporated, and which must be depended upon in large part to furnish the necessary plant food for the production of crops. Even a rich subsoil has little or no value if it lies beneath a worn-out surface, but if the fertility of the surface soil is maintained at a high point, then the strong, vigorous plants will have power to secure more plant food from the subsurface and subsoil.

PRINCIPLES OF SOIL FERTILITY

Probably no agricultural fact is more generally known by farmers and landowners than that soils differ in productive power. Even tho plowed alike and at the same time, prepared the same way, planted the same day with the same kind of seed, and cultivated alike, watered by the same rains and warmed by the same sun, nevertheless the best acre may produce twice as large a crop as the poorest acre on the same farm, if not, indeed, in the same field; and the fact should be repeated and emphasized that with the normal rainfall of Illinois the productive power of the land depends primarily upon the stock of plant food contained in the soil and upon the rate at which it is liberated, just as the success of the merchant depends primarily upon his stock of goods and the rapidity of sales. In both cases the stock of any commodity must be increased or renewed whenever the supply of such commodity becomes so depleted as to limit the success of the business, whether on the farm or in the store.

CROP REQUIREMENTS

Ten different elements of plant food are essential for the growth and formation of every plant. These elements are: *carbon, oxygen, hydrogen, nitrogen, phosphorus, sulfur, potassium, magnesium, calcium, and iron;* and they are represented by the chemical symbols: C, O, H, N, P, S, K, Mg, Ca, and Fe. Some seasons in central Illinois are sufficiently favorable to allow the production of at least 50 bushels of wheat per acre, 100 bushels of corn, 100 bushels of oats, and 4 tons of clover hay. When such crops are not produced under favorable seasonal conditions, the failure is due to unfavorable soil condition, which may

TABLE A.—PLANT FOOD IN WHEAT, CORN, OATS, AND CLOVER

Produce		Nitrogen	Phosphorus	Sulfur	Potassium	Magnesium	Calcium	Iron
Kind	Amount							
		lbs.	*lbs.*	*lbs.*	*lbs.*	*lbs.*	*lbs.*	*lbs.*
Wheat, grain.....	1 bu.	1.42	.24	.10	.26	.08	.02	.01
Wheat straw.....	1 ton	10.00	1.60	2.70	18.00	1.60	3.80	.60
Corn, grain.......	1 bu.	1.00	.17	.08	.19	.07	.01	.01
Corn stover......	1 ton	16.00	2.00	2.42	17.33	3.33	7.00	1.60
Corn cobs........	1 ton	4.00	.....	.....	4.00	.....	.....	.....
Oats, grain.......	1 bu.	.66	.11	.06	.16	.04	.02	.01
Oat straw........	1 ton	12.40	2.00	4.14	20.80	2.80	6.00	1.12
Clover seed.......	1 bu.	1.75	.50	.....	.75	.25	.13	.....
Clover hay.......	1 ton	40.00	5.00	3.28	30.00	7.75	29.25	1.00

result from poor drainage, poor physical condition, or an actual deficiency of plant food.

Table A shows the plant-food requirements of some of our most common field crops with respect to the seven elements furnished by the soil. The figures show the weight in pounds of the various elements contained in a bushel or in a ton, as the case may be. From these data the amount of any element removed from an acre of land by a crop of a given yield can easily be computed.

It needs no argument to show that the continuous removal of such quantities of plant food without provision for their replacement must result sooner or later in soil depletion.

PLANT-FOOD SUPPLY

Of the ten elements of plant food, three *(carbon, oxygen,* and *hydrogen)* are secured from air and water, and seven from the soil. *Nitrogen,* one of these seven elements obtained from the soil by all plants, may also be secured from the air by one class of plants (legumes), in case the amount liberated from the soil is insufficient; but even these plants (which include only the clovers, peas, beans, and vetches among our common agricultural plants) are dependent upon the soil for the other six elements *(phosphorus, potassium, magnesium, calcium, iron, and sulfur),* and they also utilize the soil nitrogen so far as it becomes soluble and available during their period of growth.

TABLE B.—PLANT-FOOD ELEMENTS IN MANURE, ROUGH FEEDS, AND FERTILIZERS

Material	Pounds of plant food per ton of material		
	Nitrogen	Phosphorus	Potassium
Fresh farm manure	10	2	8
Corn stover	16	2	17
Oat straw	12	2	21
Wheat straw	10	2	19
Clover hay	40	5	30
Cowpea hay	43	5	33
Alfalfa hay	50	4	24
Sweet clover (water-free basis)[1]	80	8	28
Dried blood	280	...	...
Sodium nitrate	310	...	...
Ammonium sulfate	400	...	...
Raw bone meal	80	180	...
Steamed bone meal	20	250	...
Raw rock phosphate	...	250	...
Acid phosphate	...	125	...
Potassium chlorid	...	...	850
Potassium sulfate	...	...	850
Kainit	...	...	200
Wood ashes[2]	...	10	100

[1]Young second year's growth ready to plow under as green manure.
[2]Wood ashes also contain about 1,000 pounds of lime (calcium carbonate) per ton.

The vast difference with respect to the supply of these essential plant food elements in different soils is well brought out in the data of the Illinois soil survey. For example, it has been found that the nitrogen in the surface 6⅔ inches, which represents the plowed stratum, varies in amount from 180 pounds per acre to nearly 33,000 pounds. In like manner the phosphorus content varies from about 420 pounds to 4,900 pounds, the potassium ranges from 1,530 pounds to about 58,000 pounds. Similar variations are found in all of the other essential plant food elements of the soil.

With these facts in mind it is easy to understand how a deficiency of one of these elements of plant food may become a limiting factor of crop production. When an element becomes so reduced in quantity as to become a limiting factor of production, then we must look for some outside source of supply. Table B is presented for the purpose of furnishing information regarding the quantity of plant food contained in some of the materials most commonly used as sources of plant-food supply.

LIBERATION OF PLANT FOOD

The chemical analysis of the soil gives the invoice of fertility actually present in the soil strata sampled and analyzed, but the rate of liberation is governed by many factors, some of which may be controlled by the farmer, while others are largely beyond his control. Chief among the important controllable factors which influence the liberation of plant food are limestone and decaying organic matter. Tillage also has a considerable effect in this connection.

Effect of Limestone.—Limestone corrects the acidity of the soil and thus encourages the development not only of the nitrogen-gathering bacteria which live in the nodules on the roots of clover, cowpeas, and other legumes, but also the nitrifying bacteria, which have power to transform the insoluble and unavailable organic nitrogen into soluble and available nitrate nitrogen. At the same time, the products of this decomposition have power to dissolve the minerals contained in the soil, such as potassium and magnesium, and also to dissolve the insoluble phosphate and limestone which may be applied in low-priced forms. Thus, in the conversion of sufficient organic nirogen into nitrate nitrogen for a 100-bushel crop of corn, the nitrous acid formed is alone sufficient to convert seven times as much insoluble tricalcium phosphate into soluble monocalcium phosphate as would be required to supply the phosphorus for the same crop.

Effect of Organic Matter.—Organic matter may be supplied by animal manures, consisting of the excreta of animals and usually accompanied by more or less stable litter, and by plant manures, including green-manure crops and cover crops plowed under and also crop residues such as stalks, straw, and chaff. The rate of decay of organic matter depends largely upon its age, condition, and origin, and it may be hastened by tillage. The chemical analysis shows correctly the total organic carbon, which constitutes, as a rule, but little more than half the organic matter; so that 20,000 pounds of organic carbon in the plowed soil of an acre corresponds to nearly 20 tons of organic matter. But this organic matter consists largely of the old organic residues that have accumulated during the past centuries because they were resistant to decay, and 2 tons of clover or cowpeas plowed under may have greater power to liberate plant food than the 20 tons of old, inactive organic matter. The history of the individual

farm or field must be depended upon for information concerning recent additions of active organic matter, whether in applications of farm manure, in legume crops, or in sods of old pastures.

The condition of the organic matter of the soil is indicated more or less definitely by the *ratio of carbon to nitrogen.* As an average, the fresh organic matter incorporated with soils contains about twenty times as much carbon as nitrogen, but the carbohydrates ferment and decompose much more rapidly than the nitrogenous matter; and the old resistant organic residues, such as are found in normal subsoils, commonly contain only five or six times as much carbon as nitrogen. Soils of normal physical composition, such as loam, clay loam, silt loam, and fine sandy loam, when in good productive condition, contain about twelve to fourteen times as much carbon as nitrogen in the surface soil; while in old, worn soils that are greatly in need of fresh, active, organic manures, the ratio is narrower, sometimes falling below ten of carbon to one or nitrogen. Except in newly made alluvial soils, the ratio is usually narrower in the subsurface and subsoil than in the surface stratum. Soils of cut-over or burnt-over timber lands sometimes contain so much partially decayed wood or charcoal as to destroy the value of the nitrogen-carbon ratio for the purpose indicated.

The organic matter furnishes food for bacteria, and as it decays certain decomposition products are formed, including much carbonic acid, some nitrous acid, and various organic acids, and these acting upon the soil have the power to dissolve the essential mineral plant foods, thus furnishing soluble phosphates, nitrates, and other salts of potassium, magnesium, calcium, etc., for the use of the growing crop.

Effect of Tillage.—Tillage, or cultivation, also hastens the liberation of plant food by permitting the air to enter the soil. It should be remembered, however, that tillage is wholly destructive, in that it adds nothing whatever to the soil, but always leaves it poorer, so far as plant food is concerned. Tillage should be practiced so far as is necessary to prepare a suitable seed bed for root development and also for the purpose of killing weeds, but more than this is unnecessary and unprofitable; and it is much better actually to enrich the soil by proper applications of limestone, organic matter and other fertilizing materials, and thus promote soil conditions favorable for vigorous plant growth, than to depend upon excessive cultivation to accomplish the same object at the expense of the soil.

PERMANENT SOIL IMPROVEMENT

According to the kind of soil involved, any comprehensive plan contemplating a permanent system of agriculture will need to take into account some of the following considerations.

The Application of Limestone

The Function of Limestone.—In considering the application of limestone to land it should be understood that this material functions in several different ways, and that a beneficial result may therefore be attributable to quite diverse causes: Limestone provides the plant food calcium, of which certain crops are strong feeders. It corrects acidity of the soil, thus making for some crops a much

more favorable environment as well as establishing conditions absolutely required for some of the beneficial legume bacteria. It accelerates nitrification and nitrogen fixation. It promotes sanitation of the soil by preventing the growth of certain fungus diseases, such as corn root rot. Experience indicates that it modifies directly the physical structure of some soils, frequently to their great improvement.

Thus, working in one or more of these different ways, limestone often becomes the key to the improvement of worn lands. Remarkable success has been experienced with limestone used in conjunction with sweet clover in the reclamation of abandoned hill land which had been ruined thru erosion.

Amounts to Apply.—If the soil is acid, at least 2 tons per acre of ground limestone should be applied as an initial treatment. Continue to apply limestone from time to time according to the requirement of the soil as indicated by the tests described below, or until the most favorable conditions are established for the growth of legumes, using preferably at times magnesian limestone ($CaCO_3MgCO_3$), which contains both calcium and magnesium and has slightly greater power to correct soil acidity, ton for ton, than the ordinary calcium limestone ($CaCO_3$). On strongly acid soils, or on land being prepared for alfalfa, 4 or 5 tons per acre of ground limestone may well be used for the first application.

How to Ascertain the Need for Limestone.—The need of a soil for limestone may be ascertained by applying one of the following tests for soil acidity. Along with the acidity test, a test for the presence of carbonates should be made. It should be understood that a positive test for carbonates does not guarantee the absence of acid; for it may happen, especially when the soil is near the neutral point, that positive tests for both acidity and carbonates are obtained. This condition is explained by the assumption that solid particles of calcium or magnesium carbonates form centers of alkalinity within a soil that is generally acid. Because of this fact any test made of a given soil ought to be repeated if it is to be thoroly reliable. It is also desirable to test samples from different depths. Following are the directions for making these tests:

The Litmus Paper Test for Acidity. Make a ball of fresh moist soil, break it in two, insert a piece of blue litmus paper, and press the soil firmly together again. After a few minutes examine the paper. If it has turned pink or red, soil acidity is indicated. The intensity of the color and the rapidity with which it develops indicates to some extent the amount of acidity. Needless to say the reliability of the test depends upon the quality of litmus paper used.

The Potassium Thiocyanate Test for Acidity. A more recently discovered test for soil acidity which promises to be more satisfactory than the litmus test is made with a 4-percent solution of potassium thiocyanate in alcohol—4 grams of potassium thiocyanate in 100 cubic centimeters of 95-percent alcohol (not denatured). When a small quantity of soil shaken up in a test tube with this solution gives a red color the soil is acid and limestone should be applied. If the solution remains colorless the soil is not acid. The conditions for a prompt reaction require a temperature that is comfortably warm.

The Hydrochloric Acid Test for Carbonates. Make a shallow cup of a ball of soil and pour into it a few drops of concentrated hydrochloric acid. If carbonates are present they are decomposed with the liberation of carbon dioxid, which appears as gas bubbles, producing foaming or effervescence. With much carbonate present the action is lively, but with mere traces of it the bubbles are given off slowly. If no carbonate, or very little, is indicated by the test, then it is advisable to apply limestone.

The Nitrogen Problem

Nitrogen presents the greatest practical soil problem in American agriculture. Four important reasons for this are: its increasing deficiency in most soils; its cost when purchased on the open market; its removal in large amounts by crops; and its loss from soils thru leaching. Nitrogen costs from four to

five times as much per pound as phosphorus. A 100-bushel crop of corn requires 150 pounds of nitrogen for its growth, but only 23 pounds of phosphorus. The loss of nitrogen from soils may vary from a few pounds to over one hundred pounds per acre, depending upon the treatment of the soil, the distribution of rainfall, and the protection afforded by growing crops.

An inexhaustible supply of nitrogen is present in the air. Above each acre of the earth's surface there are about sixty-nine million pounds of atmospheric nitrogen. The nitrogen above one square mile weighs twenty million tons, an amount sufficient to supply the entire world for four or five decades. This large supply of nitrogen in the air is the one to which the world must eventually turn.

There are two methods of collecting the inert nitrogen gas of the air and combining it into compounds that will furnish products for agricultural uses. *These are the chemical and the biological fixation of the atmospheric nitrogen.* Farmers have at their command one of these methods. By growing inoculated legumes, nitrogen may be obtained from the air, and by plowing under more than the roots of those legumes, nitrogen may be added to the soil.

Inasmuch as legumes are worth growing for feed and seed as well as for nitrate production, a considerable portion of the nitrogen thus gained may be considered a by-product. Because of that fact, it is questionable whether the chemical fixation of nitrogen, the possibilities of which now represent numerous compounds, will ever be able to replace the simple method of obtaining atmospheric nitrogen by growing inoculated legumes.

For easy figuring it may well be kept in mind that the following amounts of nitrogen are required for the produce named:

1 bushel of oats (grain and straw) requires 1 pound of nitrogen.
1 bushel of corn (grain and stalks) requires 1½ pounds of nitrogen.
1 bushel of wheat (grain and straw) requires 2 pounds of nitrogen.
1 ton of timothy requires 24 pounds of nitrogen.
1 ton of clover contains 40 pounds of nitrogen.
1 ton of cowpeas contains 43 pounds of nitrogen.
1 ton of alfalfa contains 50 pounds of nitrogen.
1 ton of average manure contains 10 pounds of nitrogen.
1 ton of young sweet clover, at about the stage of growth when it is plowed under as green manure, contains, on water-free basis, 80 pounds of nitrogen.

The roots of clover contain about half as much nitrogen as the tops, and the roots of cowpeas contain about one-tenth as much as the tops. Soils of moderate productive power will furnish as much nitrogen to clover (and two or three times as much to cowpeas) as will be left in the roots and stubble. In grain crops, such as wheat, corn, and oats, about two-thirds of the nitrogen is contained in the grain and one-third in the straw or stalks.

The Phosphorus Problem

The element phosphorus is an indispensable constituent of every living cell. It is intimately connected with the life processes of both plants and animals, the nuclear material of the cells being especially rich in this element.

The phosphorus content of a soil varies according to its origin and the kind of farming practiced. Even virgin soils are found that are deficient in phosphorus.

On all lands deficient in phosphorus (except on those susceptible to serious erosion by surface washing or gullying) that element should be applied in considerably larger amounts than are required to meet the actual needs of the crops desired to be produced. The abundant information thus far secured shows positively that fine-ground natural rock phosphate can be used successfully and very profitably, and clearly indicates that this material will be the most economical form of phosphorus to use in all ordinary systems of permanent, profitable soil improvement. The first application may well be one ton per acre, and subsequently about one-half ton per acre every four or five years should be applied, at least until the phosphorus content of the plowed soil reaches 2,000 pounds per acre, which may require a total application of from 3 to 5 or 6 tons per acre of raw phosphate containing 12½ percent of the element of phosphorus.

Steamed bone meal and even acid phosphate may be used in emergencies, but it should always be kept in mind that a pound of phosphorus delivered in Illinois in the form of raw phosphate (direct from the mine in carload lots), is much cheaper than the same amount in steamed bone meal or in acid phosphate, both of which cost too much per ton to permit their common purchase by farmers in carload lots, which is not the case with raw phosphate. Landowners should bear in mind the fact that phosphorus additions to the soil in amounts above the immediate crop requirements represent a permanent investment, since this element is not readily lost in the drainage water as in the case of nitrogen. It is removed from the farm thru the sale of crops, milk, and animals.

Phosphate may be applied at any time during a rotation, but it is applied to the best advantage either preceding a crop of clover, which plant seems to possess an unusual power for assimilating raw phosphate, or else at a time when it can be plowed under with some form of organic matter such as animal manure or green manure, the decay of which serves to liberate the phosphorus from its insoluble condition in the rock. It is important that the fine-ground rock phosphate be intimately mixed with the organic material as it is plowed under.

The Potassium Problem

Normal soils, in which clay and silt form a considerable part of the constituency, are well stocked with potassium, altho it exists largely in insoluble form. Such soils as sands and peats, however, are likely to be low in this element. On such soils this deficiency may be supplied by the application of some potassium salt, such as potassium sulfate, potassium chlorid, kainit, or other potassium compound, and in many instances this is done at great profit.

From all the facts at hand it seems, so far as our great areas of normal soils are concerned, that the potassium problem is not one of addition but of liberation. The Rothamsted records, which represent the oldest soil experiment fields in the world, show that for many years other soluble salts have practically the same power as potassium to increase crop yield in the absence of sufficient decaying organic matter. Whether this action relates to supplying or liberating potassium for its own sake, or to the power of the soluble salt to increase the availability of phosphorus or other elements, is not known, but where much

potassium is removed, as in the entire crops at Rothamsted, with no return of organic residues, probably the soluble salt functions in both ways.

Further evidence on this matter is furnished by the Illinois experiment field at Fairfield, where potassium sulfate has been compared with kainit both with and without the addition of organic matter in the form of stable manure. Both sulfate and kainit produced a substantial increase in the yield of corn, but the cheaper salt, kainit, was just as effective as the potassium sulfate, and returned some financial profit. Manure alone gave an increase similar to that produced by the potassium salts, but the salts added to the manure gave very little increase over that produced by the manure alone. This is explained in part perhaps because the potassium removed in the crops is mostly returned in the manure if properly cared for, and perhaps in larger part because the decaying organic matter helps to liberate and hold in solution other plant-food elements, especially phosphorus.

In laboratory experiments at the Illinois Experiment Station, it has been shown that potassium salts and most other soluble salts increase the solubility of the phosphorus in soil and in rock phosphate; also that the addition of glucose with rock phosphate in pot-culture experiments increases the availability of the phosphorus, as measured by plant growth, altho the glucose consists only of carbon, hydrogen, and oxygen, and thus contains no plant food of value.

In considering the conservation of potassium on the farm it should be remembered that in average live-stock farming the animals destroy two-thirds of the organic matter and retain one-fourth of the nitrogen and phosphorus from the food they consume, but that they retain less than one-tenth of the potassium; so that the actual loss of potassium in the products sold from the farm, either in grain farming or in live-stock farming, is negligible on land containing 25,000 pounds or more of potassium in the surface 6⅔ inches.

The Calcium and Magnesium Problem

When measured by the actual crop requirements for plant food, magnesium and calcium are more limited in some Illinois soils than potassium. But with these elements we must also consider the loss by leaching.

Doctor Edward Bartow and associates, of the Illinois State Water Survey, have shown that as an average of 90 analyses of Illinois well-waters drawn chiefly from glacial sands, gravels, or till, 3 million pounds of water (about the average annual drainage per acre for Illinois) contained 11 pounds of potassium, 130 of magnesium, and 330 of calcium. These figures are very significant, and it may be stated that if the plowed soil is well supplied with the carbonates of magnesium and calcium, then a very considerable proportion of these amounts will be leached from that stratum. Thus the loss of calcium from the plowed soil of an acre at Rothamsted, England, where the soil contains plenty of limestone, has averaged more than 300 pounds a year as determined by analyzing the soil in 1865 and again in 1905. And practically the same amount of calcium was found by analyzing the Rothamsted drainage waters.

Common limestone, which is calcium carbonate ($CaCO_3$), contains, when pure, 40 percent of calcium, so that 800 pounds of limestone is equivalent to 320 pounds of calcium. Where 10 tons per acre of ground limestone was applied at Edgewood, Illinois, the average annual loss during the next ten

years amounted to 790 pounds per acre. The definite data from careful investigations seems to be ample to justify the conclusion that where limestone is needed at least 2 tons per acre should be applied every four or five years.

It is of interest to note that thirty crops of clover of 4 tons each would require 3,510 pounds of calcium, while the most common prairie land of southern Illinois contains only 3,420 pounds of total calcium in the plowed soil of an acre. Thus limestone has a positive value on some soils for the plant food which it supplies, in addition to its value in correcting soil acidity and in improving the physical condition of the soil. Ordinary limestone (abundant in the southern and western parts of the state) contains nearly 800 pounds of calcium per ton; while a good grade of dolomitic limestone (the more common limestone of northern Illinois) contains about 400 pounds of calcium and 300 pounds of magnesium per ton. Both of these elements are furnished in readily available form in ground dolomitic limestone.

The Sulfur Question

In considering the relation of sulfur in a permanent system of soil fertility it is important to understand something of the cycle of transformations that this element undergoes in nature. Briefly stated this is as follows:

Sulfur exists in the soil in both organic and inorganic forms, the former being gradually converted to the latter form thru bacterial action. In this inorganic form sulfur is taken up by plants which in their physiological processes change it once more into an organic form as a constituent of protein. When these plant proteins are consumed by animals, the sulfur becomes a part of the animal protein. When these plant and animal proteins are decomposed, either thru bacterial action, or thru combustion, the sulfur passes into the atmosphere or into the soil solution in the form of sulfur dioxid gas. This gas unites with oxygen and water to form sulfuric acid, which is readily washed back into the soil by the rain, thus completing the cycle, from soil—to plants and animals —to air—to soil.

In this way sulfur becomes largely a self-renewing element of the soil, altho there is a considerable loss from the soil by leaching. Observations taken at the Illinois Agricultural Experiment Station show that 40 pounds of sulfur per acre are brought into the soil thru the annual rainfall. With a fair stock of surfur, such as exists in our common types of soil, and an annual return, which of itself would more than suffice for the needs of maximum crops, the maintenance of an adequate sulfur supply presents little reason at present for serious concern. There are regions, however, where the natural stock of sulfur in the soil is not nearly so high and where the amount returned thru rainfall is small. Under such circumstances sulfur soon becomes a limiting element of crop production, and it will be necessary sooner or later to introduce this substance from some outside source. Investigation is now under way to determine to what extent this situation may apply to conditions in Illinois.

Physical Improvement of Soils

In the management of most soil types, one very important thing, aside from proper fertilization, tillage, and drainage, is to keep the soil in good physical condition, or good tilth. The constituent most important for this purpose is

organic matter. Organic matter in producing good tilth helps to control washing of soil on rolling land, raises the temperature of drained soil, increases the moisture-holding capacity of the soil, retards capillary rise and consequently loss of moisture by surface evaporation, and helps to overcome the tendency of some soils to run together badly.

The physical effect of organic matter is to produce a granulation or mellowness, by cementing the fine soil particles into crumbs or grains about as large as grains of sand, which produces a condition very favorable for tillage, percolation of rainfall, and the development of plant roots.

Organic matter is being destroyed during a large part of the year and the nitrates produced in its decomposition are used for plant growth. Altho this decomposition is necessary, it nevertheless reduces the amount of organic matter, and provision must therefore be made for maintaining the supply. The practical way to do this is to turn under the farm manure, straw, corn stalks, weeds, and all or part of the legumes produced on the farm. The amount of legumes needed depends upon the character of the soil. There are farms, especially grain farms, in nearly every community where all legumes could be turned under for several years to good advantage.

Manure should be spread upon the land as soon as possible after it is produced, for if it is allowed to lie in the barnyard several months as is so often the case, from one-third to two-thirds of the organic matter will be lost.

Straw and corn stalks should be turned under, and not burned. Probably no form of organic matter acts more beneficially in producing good tilth than corn stalks. It is true, they decay rather slowly, but it is also true that their durability in the soil is exactly what is needed in the production of good tilth. Furthermore, the nitrogen in a ton of corn stalks is one and one-half times that of a ton of manure, and a ton of dry corn stalks incorporated in the soil will ultimately furnish as much humus as four tons of average farm manure. When burned, however, both the humus-making material and the nitrogen are lost to the soil.

It is a common practice in the corn belt to pasture the corn stalks during the winter and often rather late in the spring after the frost is out of the ground. This tramping by stock sometimes puts the soil in bad condition for working. It becomes partially puddled and will be cloddy as a result. If tramped too late in the spring, the natural agencies of freezing and thawing and wetting and drying, with the aid of ordinary tillage, fail to produce good tilth before the crop is planted. Whether the crop is corn or oats, it necessarily suffers, and if the season is dry, much damage may be done. If the field is put in corn, a poor stand is likely to result, and if put in oats, the soil is so compact as to be unfavorable for their growth. Sometimes the soil is worked when too wet. This also produces a partial puddling which is unfavorable to physical, chemical, and biological processes. The bad effect will be greater if cropping has reduced the organic matter below the amount necessary to maintain good tilth.

Systems of Crop Rotations

In a program of permanent soil improvement one should adopt at the outset a good rotation of crops, including a liberal use of legumes, in order to increase the organic matter of the soil either by plowing under the legume crops and

other crop residues (straw and corn stalks), or by using for feed and bedding practically all the crops raised and returning the manure to the land with the least possible loss. No one can say in advance for every particular case what will prove to be the best rotation of crops, because of variation in farms and farmers and in prices for produce.

Following are a few suggested rotations, applicable to the corn belt, which may serve as models or outlines to be modified according to special circumstances.

Six-Year Rotations

First year —Corn
Second year —Corn
Third year —Wheat or oats (with clover or clover and grass)
Fourth year —Clover, or clover and grass
Fifth year —Wheat (with clover) or grass and clover
Sixth year —Clover, or clover and grass

Of course there should be as many fields as there are years in the rotation. In grain farming, with small grain grown the third and fifth years, most of the unsalable products should be returned to the soil, and the clover may be clipped and left on the land or returned after threshing out the seed (only the clover seed being sold the fourth and sixth years); or, in live-stock farming, the field may be used three years for timothy and clover pasture and meadow if desired. The system may be reduced to a five-year rotation by cutting out either the second or the sixth year, and to a four-year system by omitting the fifth and sixth years, as indicated below.

Five-Year Rotations

First year —Corn
Second year —Wheat or oats (with clover, or clover and grass)
Third year —Clover, or clover and grass
Fourth year —Wheat (with clover), or clover and grass
Fifth year —Clover, or clover and grass

First year —Corn
Second year —Corn
Third year —Wheat or oats (with clover, or clover and grass)
Fourth year —Clover, or clover and grass
Fifth year —Wheat (with clover)

First year —Corn
Second year —Cowpeas or soybeans
Third year —Wheat (with clover)
Fourth year —Clover
Fifth year —Wheat (with clover)

The last rotation mentioned above allows legumes to be seeded four times. Alfalfa may be grown on a sixth field for five or six years in the combination rotation, alternating between two fields every five years, or rotating over all the fields if moved every six years.

Four-Year Rotations

First year —Wheat (with clover)
Second year —Corn
Third year —Oats (with clover)
Fourth year —Clover

First year —Corn
Second year —Corn
Third year —Wheat or oats (with clover)
Fourth year —Clover

First year —Corn
Second year —Wheat or oats (with colver)
Third year —Clover
Fourth year —Wheat (with clover)

First year —Wheat (with clover)
Second year —Clover
Third year —Corn
Fourth year —Oats (with clover)

First year —Corn
Second year —Cowpeas or soybeans
Third year —Wheat (with clover)
Fourth year —Clover

Alfalfa may be grown on a fifth field for four or eight years, which is to be alternated with one of the four; or the alfalfa may be moved every five years. and thus rotated over all five fields every twenty-five years.

Three-Year Rotations

First year —Corn
Second year —Oats or wheat (with clover)
Third year —Clover

First year —Wheat (with clover)
Second year —Corn
Third year —Cowpeas or soybeans

By allowing the clover, in the last rotation mentioned, to grow in the spring before preparing the land for corn, we have provided a system in which legumes grow on every acre every year. This is likewise true of the following suggested two-year system:

Two-Year Rotation

First year —Oats or wheat (with sweet clover)
Second year —Corn

Altho in this two-year rotation either oats or wheat is suggested, as a matter of fact, by dividing the land devoted to small grain, both of these crops can be grown simultaneously, thus providing a three-crop system in a two-year cycle.

It should be understood that in all of the above suggested cropping systems it may be desirable in some cases to substitute rye for the wheat or oats. In all of these proposed rotations the word *clover* is used in a general sense to designate either red clover, alsike clover, or sweet clover. The value of sweet clover especially as a green manure for building up depleted soils, as well as a pasture and hay crop, is becoming thoroly established, and its importance in a crop-rotation program may well be emphasized.

SUPPLEMENT: EXPERIMENT FIELD DATA

(Results from Experiment Fields Representing the More Important Types of Soil Occurring in Iroquois County)

In the earlier reports of this series it was the practice to incorporate in the body of the report the results of certain experiment fields, for the purpose of illustrating the possibilities of improving the soil of various types. The information carried by such data must, naturally, be considered more or less tentative. As the fields grow older new facts develop, which in some instances may call for the modification of former recommendations. It has therefore seemed desirable to separate this experiment field data from the more permanent information of the soil survey, and embody the same in the form of a supplement to the soil report proper, thus providing a convenient arrangement for possible future revisions as further data accumulate.

The University of Illinois has conducted altogether about fifty soil experiment fields in different sections of the state and on various types of soil. Altho some of these fields have been discontinued, the large majority are still in operation. It is the present purpose to report the summarized results from certain of these fields which are representative of the types of soil described in the accompanying soil report.

A few general explanations at this point, which apply to all the fields, will relieve the necessity of numerous repetitions in the following pages.

These fields vary in size from less than two acres up to 40 acres or more. They are laid off into series of plots and each series is occupied by one kind of crop. Usually there are several series so that a crop rotation can be carried on with every crop represented every year.

Farming Systems

On many of the fields the treatment provides for two distinct systems of farming, live-stock and grain farming. *In the live-stock system,* stable manure is used to furnish organic matter and nitrogen. The amount applied to a plot is based upon the amount that can be produced from crops raised on that plot.

In the grain system no animal manure is used. The organic matter and nitrogen are supplied in the form of plant manures, including plant residues produced, such as stalks and straw, along with leguminous catch crops plowed under.

Rotations

Crops which are of interest in the respective localities are grown in definite rotations, and on most of the fields provision is made so that every crop in the rotation is represented every year. The most common rotation used is wheat, corn, oats, and clover; and often these crops are accompanied by alfalfa growing on a fifth series. In the grain system a legume catch crop, usually sweet clover, is included, which is seeded on the young wheat in the spring and plowed under in the fall or in the following spring in preparation for corn. In the event of clover failure, soybeans are substituted.

Soil Treatment

The treatment applied to the plots has, for the most part, been standardized according to a definite system, altho deviations from this system occur now and then, particularly in the older fields.

Following is a brief explanation of this standard system of treatment.

Animal Manures.—Animal manures, consisting of excreta from animals, with stable litter, are spread upon the respective plots in amounts proportionate to previous crop yields, the applications being made in the preparation for corn.

Plant Manures.—Crop residues produced on the land, such as stalks, straw, and chaff, are returned to the soil, and in addition a green-manure crop of sweet clover is seeded in small grains to be plowed under in preparation for corn. (On plots where limestone is lacking the sweet clover seldom survives.) This practice is designated as the *residues system.*

Mineral Manures.—The yearly acre-rates of application are: for limestone, 1,000 pounds; for raw rock phosphate, 500 pounds; and for potassium, the equivalent of 200 pounds of kainit. The initial application of limestone is usually 4 tons per acre.

Explanation of Symbols Used

0 = Untreated land or check plots
M = Manure (animal)
R = Residues (from crops, and includes legumes used as green manure)
L = Limestone
P = Phosphorus
K = Potassium (usually in the form of kainit)
N = Nitrogen (usually in the form contained in dried blood)
( ) = Parentheses enclosing figures signify tons of hay, as distinguished from bushels of seed

In discussions of this sort of data, financial profits or losses based upon assigned market values are frequently considered. However, in view of the erratic fluctuations in market values—especially in the past few years—it seems futile to attempt to set any prices for this purpose that are at all satisfactory. The yields are therefore presented with the thought that with these figures at hand the financial returns from a given practice can readily be computed upon the basis of any set of market values that the reader may choose to apply.

BROWN SILT LOAM

Several experiment fields have been conducted on brown silt loam soil at various locations in Illinois. Those located at the University have been in operation the longest and they serve well to illustrate the principles involved in the maintenance and improvement of this type of soil.

The Morrow Plots

It happens that the oldest soil experiment field in the United States is located on typical brown silt loam of the early Wisconsin glaciation, on the campus of the University of Illinois. This field was started in 1879 by George E. Morrow, who for many years was Professor of Agriculture, and these plots are known as the Morrow plots.

TABLE 1.—URBANA FIELD, MORROW PLOTS: BROWN SILT LOAM; PRAIRIE; EARLY WISCONSIN GLACIATION

Crop Yields in Soil Experiments—Bushels or (tons) per acre

Years	Soil treatment applied	Corn every year	Two-year rotation		Three-year rotation		
		Corn	Corn	Oats	Corn	Oats	Clover
1879–87	None.......	....	....	....	....	....	....
1888	None.......	54.3	49.5	....	....	48.6	....
1889	None.......	43.2	....	37.4	....	....	(4.04)
1890	None.......	48.7	54.3	....	....	....	(1.51)
1891	None.......	28.6	33.2	....	....	....	(1.46)
1892	None.......	33.1	....	37.2	70.2	....	....
1893	None.......	21.7	29.6	....	34.1	....	....
1894	None.......	34.8	....	57.2	....	65.1	....
1895	None.......	42.2	41.6	....	....	22.2	....
1896	None.......	62.3	....	34.5	....	....	....
1897	None.......	40.1	47.0	....	....	....	....
1898	None.......	18.1	....	....	....	....	....
1899	None.......	50.1	44.4	....	53.5	....	....
1900	None.......	48.0	....	41.5	....	....	....
1901	None.......	23.7	33.7	....	34.3	....	....
1902	None.......	60.2	....	56.3	....	54.6	....
1903	None.......	26.0	35.9	....	....	....	(1.11)
1904	None.......	21.5	....	17.5	55.3	....	....
1904	MLP.......	17.1	....	25.3	72.7	....	....
1905	None.......	24.8	50.0	....	....	42.3	....
1905	MLP.......	31.4	44.9	....	....	50.6	....
1906	None.......	27.1	....	34.7	....	....	(1.42)[1]
1906	MLP.......	35.8	....	52.4	....	....	(1.74)[1]
1907	None.......	29.0	47.8	....	80.5	....	....
1907	MLP.......	48.7	87.6	....	93.6	....	....
1908	None.......	13.4	....	32.9	....	40.0	....
1908	MLP.......	28.0	....	45.0	....	44.4	....
1909	None.......	26.6	33.0	....	....	....	(.65)[2]
1909	MLP.......	31.6	64.8	....	....	....	(1.73)[3]
1910	None.......	35.9	....	33.8	58.6	....	....
1910	MLP.......	54.6	....	59.4	83.3	....	....
1911	None.......	21.9	28.6	....	....	20.6	....
1911	MLP.......	31.5	46.3	....	....	38.0	....
1912	None.......	43.2	....	55.0	....	....	16.3[1]
1912	MLP.......	64.2	....	81.0	....	....	20.0[1]
1913	None.......	19.4	29.2	....	33.8	....	....
1913	MLP.......	32.0	25.0	....	47.8	....	....
1914	None.......	31.6	....	33.6	....	39.6	....
1914	MLP.......	39.4	....	58.2	....	60.4	....
1915	None.......	40.0	49.0	....	....	....	24.2[1]
1915	MLP.......	66.0	81.2	....	....	....	27.1[1]
1916	None.......	11.2	....	37.5	27.8	....	....
1916	MLP.......	10.8	....	64.7	40.6	....	....
1917	None.......	40.0	48.4	....	....	68.4	....
1917	MLP.......	78.0	81.4	....	....	86.9	....
1918	None.......	13.6	....	27.2	....	....	(2.58)
1918	MLP.......	32.6	....	59.3	....	....	(4.04)
1919	None.......	24.0	30.8	....	52.2	....	....
1919	MLP.......	43.4	66.2	....	70.8	....	....
1920	None.......	28.2	....	37.2	....	52.2	....
1920	MLP.......	54.4	....	51.6	....	69.7	....

[1]Soybeans.
[2]In addition to the hay, .64 bushel of seed was harvested.
[3]In addition to the hay, 1.17 bushels of seed were harvested.

TABLE 2.—URBANA FIELD, MORROW PLOTS: GENERAL SUMMARY

Bushels or (tons) per acre

Years	Soil treatment applied	Corn every year	Two-year rotation		Three-year rotation		
			Corn	Oats	Corn	Oats	Clover
		16 crops	*9 crops*	*6 crops*	*4 crops*	*4 crops*	*4 crops*
1888 to 1903	None.......	39.7	41.0	44.0	48.0	47.6	(2.03)
		17 crops	*8 crops*	*9 crops*	*6 crops*	*6 crops*	*3 crops*
1904 to 1920	None.......	26.6	39.6	34.4	51.4	43.9	(1.55)[1]
	MLP.......	41.1	[illegible]	55.2	68.1	58.3	(2.50)[1]

[1]One crop of soybean hay.

The Morrow series now consists of three plots divided into halves and the halves are subdivided into quarters. On one plot corn is grown continuously; on the second corn and oats are grown in rotation; and on the third, corn, oats, and clover are rotated. The north half of each plot has had no fertilizing material applied from the beginning of the experiments, while the south half has been treated since 1904, receiving standard applications of farm manure with cover crops grown in the one-crop and two-crop systems. Phosphorus has been applied in two different forms: rock phosphate to the southwest quarter at the rate of 600 pounds, and steamed bone meal to the southeast quarter at the rate of 200 pounds per acre per year up to 1919, when the rock phosphate was increased sufficiently to bring up the total amount applied to four times the quantity of bone meal applied. At the same time the rate of subsequent application of both forms of phosphorus was reduced to one-fourth the quantity, or to 200 pounds of rock phosphate and 50 pounds of bone meal per acre per year. In 1904 ground limestone was applied at the rate of 1,700 pounds per acre to the south half of each plot, and in 1918 a further application was made at the rate of 5 tons per acre with the intention of standardizing the application to the rate of 1,000 pounds of limestone per acre per year.

FIG. 1.—CORN ON THE MORROW PLOTS IN 1910

Table 1 gives the yearly records of the crop yields, and Table 2 presents the same in summarized form.

Summarizing the data from these Morrow plots into two periods with the second period beginning in 1904 when the treatment began on the half-plots, some interesting comparisons may be made. In the first place we find in the continuous corn plot a marked decrease in the second period in the average yield of corn, amounting to one-third of the crop. In the two-year rotation there is a decrease in both corn and oats production, while the averages for the three-year system show an increase in corn yield and decreases in oats and clover. Unfortunately the numbers of crops included in these last averages are too small to warrant positive conclusions.

The increase brought about by soil treatment stands out in all cases, showing the possibility not only of restoring but also of greatly improving the productive power of this land that has been so abused by continuous cropping without fertilization.

The Davenport Plots

Another set of plots on the University campus at Urbana, forming a more extensive series than the Morrow plots, but of more recent origin, are the Davenport plots. Here each crop in the rotation is represented every year. These plots were laid out in 1895, but special soil treatment was not begun until 1901. They now comprize five series of ten plots each, and each series constitutes a "field" in a crop rotation system.

From 1901 to 1911 three of the series were in a three-year rotation system of corn, oats, and clover, while the remaining two series rotated in corn and oats. In 1911 these two systems were combined into a five-series field, with a crop rotation of wheat, corn, oats, and clover, with alfalfa on a fifth field. The alfalfa occupies one series during a rotation of the other four crops, shifting to another series in the fifth year, thus completing the cycle of all series in twenty-five years.

The soil treatment applied to these plots has been as follows:

Legume cover crops were seeded in the corn at the last cultivation on Plots 2, 4, 6, and 8, from 1902 to 1907, but the growth was small and the effect, if any, was to decrease the returns from the regular crops. Crop residues (**R**) have been returned to these same plots since 1907. These consist of stalks and straw, and all legumes except alfalfa hay and the seed of clover and soybeans. Beginning in 1918 a modification of the practice was made in that one cutting of the red clover crop is harvested as hay. In conjunction with these residues a catch crop of sweet clover grown with the wheat is plowed under.

Manure (**M**) was applied preceding corn, at the rate of 2 tons per acre per year in 1905, 1906, and 1907; subsequently as many tons have been applied as there have been tons of air-dry produce harvested from the respective plots.

Lime (**L**) was applied on Plots 4 to 10 at the rate per acre of 250 pounds of air-slaked lime in 1902, and 600 pounds of limestone in 1903. No further application was made until 1911, when the system of cropping was changed. Since that time applications of limestone have been made at the rate of one-half ton per acre per year.

Phosphorus (**P**) was applied on Plots 6 to 9 at the rate of 25 pounds per acre per annum in 200 pounds of steamed bone meal; but beginning with 1908 rock phosphate at the rate of 600 pounds per acre per annum was substi-

TABLE 3.—URBANA FIELD, DAVENPORT PLOTS: BROWN SILT LOAM, PRAIRIE; EARLY WISCONSIN GLACIATION

Ten-Year Average Annual Yields—Bushels or (tons) per acre
1911-1920

Serial plot No.	Soil treatment applied	Corn	Oats	Wheat	Clover 5 crops	Soybeans 5 crops	Alfalfa
1	0	55.6	50.5	26.0	(2.42)	(1.47)	(2.43)
2	R	57.1	52.3	28.7	1.47[1]	19.8	(2.46)
3	M	66.3	61.9	28.2	(2.56)	(1.62)	(2.52)
4	RL	64.8	55.6	31.4	1.61[1]	20.3	(2.72)
5	ML	69.6	64.1	32.8	(2.90)	(1.67)	(3.03)
6	RLP	71.5	69.8	43.0	2.29[1]	23.5	(3.69)
7	MLP	73.0	68.6	40.0	(3.52)	(1.97)	(3.76)
8	RLPK	70.9	72.5	40.7	1.79[1]	25.5	(3.77)
9	MLPK	70.2	72.0	39.2	(3.40)	(2.20)	(3.73)
10	Mx5LPx5	65.9	71.4	40.6	(3.31)	(2.22)	(3.77)

[1]In addition to the clover seed, a crop of hay was harvested one year on Plots 2, 4, 6, and 8, yielding 2.38, 2.20, 2.54, and 2.39 tons, respectively.

tuted for the bone meal on one-half of each of these plots. These applications continued until 1918 when adjustments were begun, first to make the rate of application of rock phosphate four times that of the bone meal, and finally to reduce the amounts of these materials to 200 pounds of rock phosphate and 50 pounds of bone meal per acre per annum. The usual practice has been to apply and plow under at one time all phosphorus and potassium required for the rotation.

Potassium (K = kalium) has been applied on Plots 8 and 9 in connection with the bone meal and rock phosphate, at the yearly rate of 42 pounds per acre, and mainly as potassium sulfate.

On Plot 10 about five times as much manure and phosphorus are applied as on the other plots, but this "extra heavy" treatment was not begun until 1906, only the usual lime, phosphorus, and potassium having been applied in previous years. The purpose in making these heavy applications is to try to determine the climatic possibilities in crop yields by removing the limitations of inadequate fertility.

It will be observed that the applications described above provide for the two rather distinct systems of farming already described. *The grain system,* in which animal manure is not produced and where the organic matter is provided by the direct return to the soil of all crop residues, is exemplified in Plots 2, 4, 6, and 8; and the *live-stock system,* in which farm manure is utilized for soil enrichment, is represented in Plots 3, 5, 7, and 9.

Table 3 shows a summary of the results obtained on the Davenport plots beginning with the year 1911, when the present cropping system was introduced.

When used in conjunction with phosphorus the crop residues and the manure appear about equally effective; but where phosphorus is not applied, the manure has been decidedly more effective, under the conditions of the experiment. It should be observed, however, in this connection, that the plowing under of clover is a very essential feature of the residues system, and that, as a matter of fact, there were five clover failures, when soybeans were substituted, during the ten years. Perhaps with a more reliable biennial legume than red clover, the results would have been more favorable for this system.

Manure	Manure, limestone, phosphorus
Yield: 1.43 tons per acre	Yield: 2.90 tons per acre

FIG. 2.—CLOVER ON THE DAVENPORT PLOTS IN 1913

By comparing Plots 2 and 3 with Plots 4 and 5, it is found that limestone has had a beneficial effect on all crops. What the financial profit amounts to depends obviously upon the market value of the crops and the cost of the limestone.

Comparing Plots 4 and 5 with Plots 6 and 7, respectively, there is found in all cases an increase in crop yield as a result of adding phosphorus. The effect on wheat is especially pronounced. Where limestone and phosphorus are applied in addition to the crop residues, an increase of 17 bushels of wheat, over the yield of the untreated land, has been obtained as a ten-year average.

The effect of adding potassium to the treatment is of much interest. Plots 8 and 9 are the same as Plots 6 and 7, respectively, except that potassium has been applied to the former. On the whole, no significant benefit is shown from the addition of potassium.

No benefit appears as the result of the extra-heavy applications of manure and phosphorus on Plot 10. In fact the corn yields are noticeably less here than on the plots receiving the normal applications of these materials.

The University South Farm

On the University South Farm, at Urbana, several series of plots devoted primarily to variety testing and other crop-production experiments are so laid out as to show the effects of certain soil treatments that have been applied.

Several different systems of crop rotation are employed and the crops are so handled as to exemplify the two general systems of farming, grain and livestock.

The summarized results presented in Table 4 represent three different systems of cropping. The first, designated as the Southwest rotation, is to be regarded as a good rotation for general practice, on this type of soil, under Illinois conditions. This is a four-field rotation of wheat, corn, oats, and clover. The second, or North-Central rotation, consisting of corn, corn, oats, and clover, represents a system very commonly practiced; and the third or South-Central rotation, consisting of corn, corn, corn, and soybeans, must be considered as a poor rotation from the standpoint of maintaining the productiveness of the land.

TABLE 4.—URBANA FIELD, SOUTH FARM: BROWN SILT LOAM, PRAIRIE; EARLY WISCONSIN GLACIATION

Average Annual Yields—Bushels or (tons) per acre

Southwest Rotation: Series 100, 200, 400[1]: Wheat, Corn, Oats, Clover[2]

Soil treatment applied[6]	Corn 9 crops	Oats[3] 9 crops	Wheat[3] 8 crops	Clover[4] 3 crops	Soybeans 7 crops
RP	62.3	51.9	41.0	1.05	17.3[5]
R	51.9	46.5	26.9	1.38	16.2[5]
M	59.7	50.2	29.1	(2.28)	(1.25)
MP	64.3	55.4	43.1	(2.86)	(1.51)
RLP	60.5	57.2	41.8	.64	16.4[5]
R	49.7	49.6	25.8	.83	14.7[5]
M	55.5	54.1	27.8	(1.71)	(1.28)
MLP	64.1	59.6	43.9	(1.77)	(1.58)

North-Central Rotation: Series 500, 600, 700[1]: Corn, Corn, Oats, Clover[2]

Soil treatment applied[6]	Corn 1st year 9 crops	Corn 2d year 9 crops	Oats 9 crops	Clover 5 crops	Soybeans 4 crops
RP	56.7	51.1	56.1	.54	16.9
R	51.7	45.2	52.0	.50	16.0
M	54.9	46.7	52.1	(2.29)	(1.60)
MP	56.5	53.4	56.9	(2.73)	(1.74)

South-Central Rotation: Series 500, 600, 700[1]: Corn, Corn, Corn, Soybeans

Soil treatment applied[6]	Corn 1st year 9 crops	Corn 2d year 9 crops	Corn 3d year 9 crops		Soybeans 9 crops
RP	51.9	44.0	41.3		20.0
R	45.5	39.9	35.2		19.2
M	50.1	42.1	33.5		(1.59)
MP	54.5	46.7	42.0		(1.66)

[1]Results from Series 300 and 800 are omitted on account of variation in soil type.
[2]Soybeans when clover fails.
[3]Only seven crops with limestone.
[4]Only one crop with limestone.
[5]Average of five crops.
[6]All phosphorus plots received ½ ton per acre of limestone in 1903.

TABLE 5.—COMPARING PRODUCTION OF CORN IN THREE DIFFERENT ROTATION SYSTEMS
ACRE YIELDS FROM PLOTS ON THE UNIVERSITY SOUTH FARM
Twelve-Year Average (1908-1919)—Bushels per acre

Rotation	Wheat-corn-oats-legume[1]	Corn-corn-oats-legume[2]		Corn-corn-corn-legume[3]		
Treatment	Corn	1st Corn	2d Corn	1st Corn	2d Corn	3d Corn
Organic manures............	[illegible]	53.3	46.0	47.8	41.0	34.3
Organic manures, phosphorus.	[illegible]	56.6	52.3	53.2	45.3	41.6

[1]Clover 3 crops, and soybeans 7 crops.
[2]Clover 5 crops, and soybeans 5 crops.
[3]Soybeans 9 crops.

On the whole, the "residues" have not returned yields quite so high as those produced by the manure treatment; but, as remarked above in the discussion of the Davenport plots, the residues system has probably been at a disadvantage thru frequent clover failures. On the North-Central rotation, where conditions seem to have been more favorable for clover, there is very little difference between the effect of manure and of residues.

Residues plowed under
Yield: 35.2 bushels per acre

Residues and rock phosphate
Yield: 50.1 bushels per acre

FIG. 3.—WHEAT ON THE UNIVERSITY SOUTH FARM IN 1911

In the rotation system in which limestone is being applied, no benefit of consequence to any of the crops except oats appears from the use of this material. The test, however, has hardly been of sufficient duration to warrant final conclusions; and furthermore, the comparison may be somewhat impaired by a possible residual effect of the small application of limestone made in 1903 to all the phosphorus plots.

The results obtained from the use of phosphorus are important because this element has been applied to these plots solely in the form of raw rock phosphate. The figures in almost every case show an increase in yield where the phosphorus has been applied, and in most cases this increase is very pronounced. The wheat is especially responsive to phosphorus.

The records furnish some interesting comparisons of corn yields produced under different systems of cropping. Table 5 gives a general summary of the corn yields only, in which the results from the residues and manure treatments are averaged together as "organic manures." The highest annual acre-yields are found where corn occurs but once in a rotation. Where corn is grown twice in succession, the annual acre-yields are less; and where corn occurs three times, there is a further reduction. Also, the first crop of corn within a rotation produces more than the second, and the second crop yields more than the third. These are useful facts for consideration in connection with problems of general farm management.

BLACK CLAY LOAM

The Hartsburg experiment field, representing black clay loam of the middle Illinoisan glaciation, is located in Logan county just east of Hartsburg. The work was begun here in 1913. There are five series of ten plots each. A crop rotation of wheat, corn, oats, and clover, with alfalfa on a fifth field, is practiced. The soil treatments are as indicated in Table 6. The table also summarizes the

TABLE 6.—HARTSBURG FIELD: BLACK CLAY LOAM, PRAIRIE; MIDDLE ILLINOISAN GLACIATION

Average Annual Yields—Bushels or (tons) per acre

Serial plot No.	Soil treatment applied	Wheat 5 crops	Corn 8 crops	Oats 7 crops	Clover 4 crops	Soybeans 2 crops	Alfalfa 8 crops[1]
1	0	22.6	43.4	45.4	(1.98)	(1.29)	(3.30)
2	M	27.4	48.3	50.2	(2.41)	(1.64)	(3.61)
3	ML	34.2	56.9	57.9	(2.51)	(1.82)	(3.83)
4	MLP	38.2	56.0	57.3	(2.62)	(1.92)	(4.04)
5	0	33.3	46.8	43.8	.74[2]	25.8	(3.19)
6	R	34.0	58.2	55.6	1.22[2]	26.8	(3.60)
7	RL	32.0	63.7	54.9	1.32[2]	28.4	(3.28)
8	RLP	36.4	61.1	59.0	1.41[2]	26.1	(3.83)
9	RLPK	35.2	59.5	57.2	1.42[2]	26.4	(4.01)
10	0	31.7	46.7	46.9	(2.14)	(1.69)	(3.02)

[1]No residues except on last two crops.

[2]In addition to the clover seed, hay was harvested on Plots 5, 6, 7, 8, and 9 amounting to .56, 1.01, 1.11, 1.20, and 1.03 tons, respectively.

yields, by crops, for the period during which the plots have been under full treatment.

Under the conditions of these experiments, residues alone have proved to be more effective than manure alone in the production of wheat, corn, and oats.

Limestone used with manure has given such greatly increased yields as to leave no doubt about the profitableness of its use. When applied with residues, however, there appears to be on the whole little advantage from the use of limestone.

Phosphorus has given good returns on the wheat crop, but with the other crops its recommendation would be doubtful. In this connection attention should be called to the fact that chemical analysis of this black clay loam type generally shows a relatively high phosphorus content. The experience on this field seems to bear out what the analyses show.

The addition of potassium has produced a depressing effect on the yields of all grain crops, and with the alfalfa the small gain could scarcely be considered significant.

YELLOW-GRAY SILT LOAM

Yellow-gray silt loam exhibits an important variation with respect to limestone content. In some areas, altho limestone may be altogether absent in the surface stratum it is found in abundance at a short distance beneath the surface. Accordingly, variations in response to soil treatment are exhibited by different experiment fields located on this type. In view of this discrepancy it is thought well to introduce here the records of two fields, that are representative of the type but which show a marked diversity in results, one in northern Illinois and one in the southern part of the state.

The Antioch field is located on the late Wisconsin glaciation, in Lake county, close to the Wisconsin border. The field was started in 1902, with but a single series of ten plots, under a rotation of corn, corn, oats, and wheat; but beginning with 1911 the rotation has been wheat, corn, oats, and clover. It was started in order to learn as quickly as possible what effect would be produced by the addition to this type of soil of nitrogen, phosphorus, and potassium, used singly and in combination. These elements were all applied in commercial form until 1911, after which the use of commercial nitrogen was discontinued and crop residues were substituted in its place. Nitrogen was supplied in the earlier years in 800 pounds per acre of dried blood. Phosphorus is applied in 200 pounds of steamed bone meal, and potassium in 100 pounds of potassium sulfate. At the beginning, 470 pounds of slaked lime was applied; but since 1912 limestone has been applied at the rate of 1,000 pounds per acre per year.

Table 7 presents, in summarized form, the results from the Antioch field. Because of an abnormality in Plot 1, the results from this plot are not considered. The data show that phosphorus is the one element standing out prominently as producing consistently beneficial results. Potassium applied in addition to phosphorus has, on the whole, not produced profitable results. Also, the results are unfavorable for the application of limestone. Limestone, however, is abundant in the subsoil of this type in the region of this field.

Lime applied and residues plowed under — Lime and phosphorus applied

FIG. 4.—CLOVER IN 1913 ON ANTIOCH FIELD

TABLE 7.—ANTIOCH FIELD: YELLOW-GRAY SILT LOAM, TIMBER SOIL; LATE WISCONSIN GLACIATION

Average Annual Yields—Bushels or (tons) per acre

Serial plot No.	Soil treatment applied	Corn 8 crops	Oats 5 crops	Wheat 4 crops	Clover 2 crops
1	0	23.9	32.3	15.8	.50
2	L	21.3	26.8	13.2	.30
3	LR	21.3	29.9	20.6	.33
4	LP	30.7	43.6	36.7	1.08
5	LK	23.7	27.8	19.2	.67
6	LRP	33.8	43.3	33.3	.67
7	LRK	24.3	26.9	20.8	.59
8	LPK	25.1	[illegible]	[illegible]	1.28
9	LRPK	38.3	42.6	[illegible]	.33
10	RPK	38.4	44.7	[illegible]	.67

The Raleigh experiment field is located on the lower Illinoisan glaciation, in southern Illinois, in Saline county. This field is laid out into four series of ten plots each, under a rotation of wheat, corn, oats, and clover. The treatments, along with the summarized results, are given in Table 8.

The outstanding feature of these results is the effect of limestone. Altho manure alone produces a substantial increase, especially in the corn crop, when limestone is added a remarkable increase is found in all crops. A most important fact is that the organic matter can be effectively built up thru the use

Manure, limestone, phosphorus
Yield: 61 bushels per acre

Nothing applied
Yield: 15 bushels per acre

FIG. 5.—CORN ON RALEIGH FIELD IN 1920

TABLE 8.—RALEIGH FIELD: YELLOW-GRAY SILT LOAM, TIMBER SOIL; LOWER ILLINOISAN GLACIATION

Average Annual Yields—Bushels or (tons) per acre

Serial plot No.	Soil treatment applied	Corn 10 crops	Oats 10 crops	Wheat 6 crops	Clover 4 crops	Soybeans 4 crops
1	0	17.3	10.4	5.8	(.26)	(.65)
2	M	29.7	13.0	7.7	(.31)	(.81)
3	ML	40.9	20.0	21.0	(1.08)	(1.08)
4	MLP	41.2	20.3	21.5	(1.32)	(1.24)
5	0	17.3	10.3	7.0	(.00) .01[2]	2.3
6	R	20.1	12.8	8.4	(.00) .01[2]	3 0
7	RL	34.9	21.5	18.8	(1.60)[1] .10[2]	5.8
8	RLP	36.5	22.7	21.2	(1.61)[1] .09[2]	6.8
9	RLPK	41.9	23 6	22.4	(1.79)[1] .12[2]	6.0
10	0	19.6	11.6	6.5	(1.06)	(.57)

[1]One crop only (1920).
[2]Average of two crops.

of crop residues, with the application of limestone, so that the crop yields are practically as high under this "grain system" of farming as where manure is used.

Phosphorus thus far has given only moderate returns in increased crop yields, but with an increasing quantity of organic matter and nitrogen it is probable that the phosphorus applications will show up more favorably on sub-

sequent crops. As to the use of potassium, it is to be noted that aside from an increase of 5.4 bushels of corn in the residues system, the beneficial effect has not been sufficient to justify the use of this material.

In accounting for the discrepancy in the response to limestone on these two fields, the fact is to be considered that the Antioch field is located on the late Wisconsin glaciation, where the subsoil contains large quantities of limestone; while the Raleigh field represents the lower Illinoisan glaciation, the soil of which is very acid to a great depth.

In view of these variations, a general recommendation for a complete treatment for soil of this type, that will apply to all localities, cannot be given out until more information is acquired.

Fortunately, however, each farmer can determine for himself the need of limestone for his land by applying the simple tests for the presence of carbonates and soil acidity, as explained under the discussion of limestone on page 36 of the Appendix.

Phosphorus, which has paid well on the Antioch field, and has given doubtful returns thus far at Raleigh, has varied considerably in its effect when used on other fields located on this same type of soil. In this situation, therefore, the present suggestion would be that each farmer might well try out phosphorus on his own land, on a limited scale, and be guided by the outcome of his experience. The low phosphorus content of the surface stratum of this soil is an indication that in a system of permanent agriculture the time is not far off when phosphorus will become a limiting element to crop production, and the wise farmer will watch carefully the indications and be ready to make timely provision for this need.

DUNE SAND

In 1913 the University came into possession of a tract of dune sand on terrace, in Henderson county, near the Mississippi river, upon which an experiment field was laid out to determine the needs of these sand soils. This field is divided into six series of plots. Corn, soybeans, wheat, sweet clover, and rye, with a catch crop of sweet clover seeded in the rye on the residues plots, are grown in rotation on five series, while the sixth series is devoted to alfalfa. When sweet clover seeded in the wheat fails, cowpeas are substituted.

No catch of alfalfa or of sweet clover was obtained till the alfalfa drill was used in seeding. This covers the seed about one-half inch deep.

Table 9 indicates the kinds of treatment applied, the amounts of the materials used being in accord with the standard practice, as explained on page 46.

The data make apparent the remarkably beneficial action of limestone on this sand soil. Where limestone has been used in conjunction with crop residues, the yield of corn has been doubled. The limestone has also produced a fair crop of rye and excellent crops of sweet clover and alfalfa.

This land appears to be quite indifferent to phosphorus treatment. The analysis shows, however, that the stock of phosphorus in this type of soil is not large, and it may develop as time goes on and the supply diminishes along with the production of good-sized crops, that the application of this element will become profitable.

Manure
Yield: Nothing

Manure and limestone
Yield: 4.43 tons per acre

FIG. 6.—ALFALFA ON OQUAWKA FIELD IN 1918

TABLE 9.—OQUAWKA FIELD: DUNE SAND, TERRACE

Average Annual Yields—Bushels or (tons) per acre

Serial plot No.	Soil treatment applied	Corn 6 crops	Soybeans[1] 5 crops	Wheat 6 crops	Sweet clover 4 crops		Rye 4 crops	Alfalfa 3 crops
1	0	14.3	(.89)	6.4	0		12.1	(.11)
2	M	18.9	(1.01)	8.1	0		13.3	(.13)
3	ML	23.4	(1.27)	9.7	(1.20)		20.1	(1.88)
4	MLP	22.2	(1.20)	10.1	(1.26)		19.5	(2.03)
					2 crops	2 crops		
5	0	14.4	3.5	7.4	(0)	0	13.7	(.14)
6	R	16.2	3.5	8.1	(0)	0	14.1	(.12)
7	RL	29.3	6.6	9.1	(1.47)	2.53	23.2	(2.05)
8	RLP	29.3	6.4	10.4	(1.39)	2.20	24.2	(1.90)
9	RLPK	32.7	6.0	9.4	(1.53)	2.84	23.7	(1.86)
10	0	11.4	(.60)	6.4	(0)		10.6	(.06)

[1] In 1918 sweet clover was killed by being cut for hay. Soybeans were seeded on these plots and the following yields obtained: .86, 1.10, 1.93, and 2.00 tons of hay per acre on Plots 1 to 4; 11.1, 9.9, 14.6, 15.8, and 16.6 bushels of seed per acre on Plots 5 to 9; and .62 ton of hay per acre on Plot 10.

Altho the results show an increase of 3.4 bushels of corn from the use of potassium salts, with ordinary prices this would not be a profitable treatment. The .64 bushel gain in sweet-clover seed is the average of two crops only, and this is insufficient data upon which to base conclusions. The other crops all show negative results from the potassium application.

Experience thus far shows rye to be better adapted to this land than wheat, and both alfalfa and sweet clover thrive better than soybeans. With these two legume crops thriving so well under this simple treatment, we have promise of tremendous possibilities for the profitable culture of this land, which hitherto has been considered as practically worthless.

Deep Peat

As representing the deep peat type of soil, the results are introduced from an experiment field conducted at Manito in Mason county during the years 1902 to 1905 inclusive.

The results of the four years' tests, as given in Table 10, are in complete harmony with the information furnished by the chemical composition of peat soil. Where potassium was applied, the yield was from three to four times as large as where nothing was applied. Where approximately equal money values of kainit and potassium chlorid were applied, slightly greater yields were obtained with the potassium chlorid, which, however, supplied about one-third more potassium than the kainit. On the other hand, either material furnished more potassium than was required by the crops produced.

The use of 700 pounds of sodium chlorid (common salt) produced no appreciable increase over the best untreated plots, indicating that where potassium is itself actually deficient, salts of other elements cannot take its place.

Applications of 2 tons per acre of ground limestone produced no increase in the corn crops, either when applied alone or in combination with kainit, either the first year or the second.

Reducing the application of kainit from 600 to 300 pounds for each two-year period reduced the yield of corn from 164.5 to 125.9 bushels. The two applications of 300 pounds of kainit (Plot 9) furnished 60 pounds of potassium for the four years, an amount sufficient for 84 bushels of corn (grain and stalks). Attention is called to the fact that this is practically the difference between the yield of Plot 9 (125.9 bushels) and the yield obtained from Plot 2 (42.9 bushels), the poorest untreated plot.

TABLE 10.—MANITO FIELD: DEEP PEAT

Corn Yields—Bushels

Plot No.	Soil treatment for 1902	Corn 1902	Corn 1903	Soil treatment for 1904	Corn 1904	Corn 1905	Four crops
1	None	10.9	8.1	None	17.0	12.0	48.0
2	None	10.4	10.4	Limestone, 4000 lbs.	12.0	10.1	42.9
3	Kainit, 600 lbs.	30.4	32.4	Limestone, 4000 lbs.; Kainit, 1200 lbs.	49.6	47.3	159.7
4	Kainit, 600 lbs.; Acidulat'd bone, 350 lb.	30.3	33.3	Kainit, 1200 lbs.; Steamed bone, 395 lbs.	53.5	47.6	164.7
5	Potassium chlorid, 200 lbs.	31.2	33.9	Potassium chlorid, 400 lbs.	48.5	52.7	166.3
6	Sodium chlorid, 700 lbs.	11.1	13.1	None	24.0	22.1	70.3
7	Sodium chlorid, 700 lbs.	13.3	14.5	Kainit, 1200 lbs.	44.5	47.3	......
8	Kainit, 600 lbs.	36.8	37.7	Kainit, 600 lbs.	44.0	46.0	164.5
9	Kainit, 300 lbs.	26.4	25.1	Kainit, 300 lbs.	41.5	32.9	125.9
10	None	14.9[1]	14.9	None	26.0	13.6	69.4

[1]Estimated from 1903; no yield was taken in 1902 because of a misunderstanding.

Several different systems of crop rotation are employed and the crops are so handled as to exemplify the two general systems of farming, grain and livestock.

The summarized results presented in Table 4 represent three different systems of cropping. The first, designated as the Southwest rotation, is to be regarded as a good rotation for general practice, on this type of soil, under Illinois conditions. This is a four-field rotation of wheat, corn, oats, and clover. The second, or North-Central rotation, consisting of corn, corn, oats, and clover, represents a system very commonly practiced; and the third or South-Central rotation, consisting of corn, corn, corn, and soybeans, must be considered as a poor rotation from the standpoint of maintaining the productiveness of the land.

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Southwest Rotation: Series 100, 200, 400[1]: Wheat, Corn, Oats, Clover[2]

Soil treatment applied[6]	Corn 9 crops	Oats[3] 9 crops	Wheat[3] 8 crops	Clover[4] 3 crops	Soybeans 7 crops
RP	62.3	51.9	41.0	1.05	17.3[5]
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MP	64.3	55.4	43.1	(2.86)	(1.51)
RLP	60.5	57.2	41.8	.64	16.4[5]
R	49.7	49.6	25.8	.83	14.7[5]
M	55.5	54.1	27.8	(1.71)	(1.28)
MLP	64.1	59.6	43.9	(1.77)	(1.58)

North-Central Rotation: Series 500, 600, 700[1]: Corn, Corn, Oats, Clover[2]

Soil treatment applied[6]	Corn 1st year 9 crops	Corn 2d year 9 crops	Oats 9 crops	Clover 5 crops	Soybeans 4 crops
RP	56.7	51.1	56.1	.54	16.9
R	51.7	45.2	52.0	.50	16.0
M	54.9	46.7	52.1	(2.29)	(1.60)
MP	56.5	53.4	56.9	(2.73)	(1.74)

South-Central Rotation: Series 500, 600, 700[1]: Corn, Corn, Corn, Soybeans

Soil treatment applied[6]	Corn 1st year 9 crops	Corn 2d year 9 crops	Corn 3d year 9 crops		Soybeans 9 crops
RP	51.9	44.0	41.3		20.0
R	45.5	39.9	35.2		19.2
M	50.1	42.1	33.5		(1.59)
MP	54.5	46.7	42.0		(1.66)

[1]Results from Series 300 and 800 are omitted on account of variation in soil type.
[2]Soybeans when clover fails.
[3]Only seven crops with limestone.
[4]Only one crop with limestone.
[5]Average of five crops.
[6]All phosphorus plots received ½ ton per acre of limestone in 1903.

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ACRE YIELDS FROM PLOTS ON THE UNIVERSITY SOUTH FARM
Twelve-Year Average (1908-1919)—Bushels per acre

Rotation	Wheat-corn-oats-legume[1]	Corn-corn-oats-legume[2]		Corn-corn-corn-legume[3]		
Treatment	Corn	1st Corn	2d Corn	1st Corn	2d Corn	3d Corn
Organic manures............	55.8	53.3	46.0	47.8	41.0	34.3
Organic manures, phosphorus.	63.2	56.6	52.3	53.2	45.3	41.6

[1]Clover 3 crops, and soybeans 7 crops.
[2]Clover 5 crops, and soybeans 5 crops.
[3]Soybeans 9 crops.

On the whole, the "residues" have not returned yields quite so high as those produced by the manure treatment; but, as remarked above in the discussion of the Davenport plots, the residues system has probably been at a disadvantage thru frequent clover failures. On the North-Central rotation, where conditions seem to have been more favorable for clover, there is very little difference between the effect of manure and of residues.

Residues plowed under
Yield: 35.2 bushels per acre

Residues and rock phosphate
Yield: 50.1 bushels per acre

FIG. 3.—WHEAT ON THE UNIVERSITY SOUTH FARM IN 1911

IN RECOGNITION

The Soil Survey of Illinois was organized under the supervision of the late Dr. Cyril G. Hopkins. The work progressed for eighteen years under his guidance and the first eighteen soil reports bear his name as senior author. On October 6, 1919, Dr. Hopkins died in a foreign land in the service of the American Red Cross. It is the purpose to carry on to completion this great work of the Illinois Soil Survey in the spirit, and along the same general plan and lines of procedure, in which it was begun.

INTRODUCTORY NOTE

It is a matter of common observation that soils vary tremendously in their productive power, depending upon their physical condition, their chemical composition, and their biological activities. For any comprehensive plan of soil improvement looking toward the permanent maintenance of our agricultural lands, a definite knowledge of the various existing kinds or types of soil is a first essential. It is the purpose of a soil survey to classify the various kinds of soil of a given area in such a manner as to permit definite characterization for description and for mapping. With the information that such a survey affords, every farmer or land owner of the surveyed area has at hand the basis for a rational system of improvement of his land. At the same time the Experiment Station is furnished an inventory of the soils of the state, upon which intelligently to base plans for those fundamental investigations so necessary for solving the problems of practical soil improvement.

This county soil report is one of a series reporting the results of the soil survey which, when completed, will cover the state of Illinois. Each county report is intended to be as nearly complete in itself as it is practicable to make it, even at the expense of some repetition. There is presented in the form of an Appendix a general discussion of the important principles of soil fertility, in order to help the farmer and land owner to understand the significance of the data furnished by the soil survey and to make intelligent application of the same in the maintenance and improvement of the land. In many cases it will be of advantage to study the Appendix in advance of the soil report proper.

Data from experiment fields representing the more extensive types of soil, and furnishing valuable information regarding effective practices in soil management, are embodied in form of a Supplement. This Supplement should be referred to in connection with the descriptions of the respective soil types found in the body of the report.

CONTENTS OF SOIL REPORT NO. 23

DeKALB COUNTY SOILS

APPENDIX

SUPPLEMENT

DEKALB COUNTY SOILS

By J. G. MOSIER, H. W. STEWART, E. E. DE TURK, and H. J. SNIDER
Prepared for Publication by L. H. SMITH[1]

LOCATION AND CLIMATE OF DE KALB COUNTY

DeKalb county is situated in the northern part of Illinois about twenty-five miles south of the Wisconsin line and fifty miles west of Lake Michigan. It is approximately 36 miles long and 18 miles wide, and has an area of 632.7 square miles. About five-sixths of the county lies in the early Wisconsin glaciation, and the remainder in the Iowan.

The temperature of DeKalb county is characterized by a wide range between the extremes of summer and winter. The greatest range of any year since 1884 at Sycamore in this county was 125 degrees. The lowest temperature recorded was —28°; the highest, 106°. The average date of the last killing frost in spring is May 2; the earliest in fall, October 5. The growing season therefore is about 156 days long.

The average annual precipitation at Sycamore from 1882 to 1920 was 33.65 inches. The average rainfall by months for this period was as follows: January, 1.69 inches; February, 1.68; March, 2.54; April, 3.06; May, 4.18; June, 3.94; July, 3.34; August, 3.22; September, 3.38; October, 2.77; November, 2.11; December, 1.74. The percentage of total rainfall for each season is: winter, 15.1; spring, 29.2; summer, 31.3; autumn, 24.4. The year of heaviest rainfall on record was 1883, when the precipitation was 50.91 inches; the driest year was 1901, when the rainfall was but 21.35 inches.

AGRICULTURAL PRODUCTION

DeKalb county is primarily agricultural. Practically the entire county is made up of tillable land, a large percentage of which is prairie. In 1920 there were 2,400 farms having an average of 157.7 acres, 147.4 acres of which was improved land. Fifty-one percent of these farms were operated by tenants. This was a decrease of almost 2 percent in the last ten years.

The principal crops are corn, oats, spring wheat, pasture, hay, barley, winter wheat, rye, clover, and soybeans. The Fourteenth Census of the United States (1920) reports the following as the acreage and yield of the principal crops. It must be remembered that these figures are for but a single year, that of 1919.

[1] J. G. Mosier, in charge of soil survey mapping; H. W. Stewart, in charge of field party; E. E. DeTurk, in charge of soil analysis; H. J. Snider, in charge of experiment fields; L. H. Smith, in charge of publications.

Crops	Acreage	Production
Corn	109,839	5,085,706 bu.
Oats	64,922	2,529,138 bu.
Wheat	47,330	933,640 bu.
Barley	10,852	299,257 bu.
Rye	2,183	44,836 bu.
Timothy	8,213	12,670 tons
Timothy and clover mixed	28,073	50,691 tons
Clover	2,115	3,617 tons
Alfalfa	838	2,127 tons
Silage crops	14,023	119,490 tons
Corn cut for forage	8,794	23,882 tons

The acreage of pasture is not given by the census, but from other data it is found to be approximately 67,000.

The live-stock interests, including those of the dairy, are of considerable importance, as is shown by the following data, also taken from the census of 1920.

Animals and animal products	Number	Value
Horses	17,720	$1,743,381
Mules	363	44,675
Beef cattle	32,945	2,392,679
Dairy cattle	18,252	1,337,833
Sheep	14,012	174,389
Swine	71,177	1,828,779
Chickens and other poultry	302,353	326,038
Eggs and chickens	......	670,115
Dairy products	......	949,757

The total value of the live stock and their products is nearly eight and a half million dollars.

Fruit growing is not very important. There were about 80,000 quarts of small fruits, 12,800 bushels of apples, pears, and cherries, and 90,000 pounds of grapes produced in 1920.

SOIL FORMATION

The most important period in the geological history of the county from the standpoint of soil formation was that during which the material that later formed the soils was being deposited. This was the Glacial period. At that time snow and ice accumulated in the region of Labrador, west of Hudson Bay, and in the Rocky Mountains to such an amount that the mass pushed outward from these centers, especially southward, until a point was reached where the ice melted as rapidly as it advanced. As the ice advanced in these movements it buried everything, even the highest mountains, in its path. It would then recede slowly, and apparently normal conditions would be restored for a long period, after which another advance would occur. At least six of these great ice movements took place, each of which covered part of northern United States, altho the same parts were not covered every time.

The names of the glaciers that have had some part, either directly or indirectly, in the formation of the soils of Illinois are as follows: (1) the Nebraskan, which did not touch Illinois; (2) the Kansan, which covered the western parts of Hancock and Adams counties; (3) the Illinoisan, which covered all of the state except the northwest county (Jo Daviess), the southern part of Calhoun county, and the seven southernmost counties; (4) the Iowan, which covered a part of northern Illinois, the area covered being difficult to determine because of the effect of the subsequent glaciations; (5) the early Wisconsin,

which covered the northeast part of the state as far west as Peoria and as far south as Shelbyville; (6) the late Wisconsin, which extended to the west line of McHenry county and south to the town of Milford in Iroquois county.

In advancing from the distant northern centers of accumulation, the ice gathered up all sorts and sizes of material, including clay, silt, sand, gravel, boulders, and even large masses of rock. Some of these materials were carried several hundred miles, and the coarser masses rubbed against the surface rocks or against each other until largely ground into rock powder, which now constitutes much of the soil. When, thru the melting of the ice, the limit of advance was reached, the material carried by the glacier was dropped, accumulating in a broad, undulating ridge or moraine, called a lateral moraine if formed at the side of the glacier, and a terminal moraine if formed at the end. If the ice melted more rapidly than the glacier advanced, the terminus of the glacier would recede, and the material would be deposited somewhat irregularly over the land, back of the moraines. Such a formation is known as a ground moraine. A glacier often would advance again, but not so far as before; or it would remain stationary, and another moraine would be built up. These moraines or ridges have a steep outward slope and a very gradual inward slope.

A pressure of forty pounds per square inch is exerted by a mass of ice one hundred feet thick, and these ice sheets may have been hundreds or even thousands of feet in thickness. The materials carried along in the ice, especially the boulders and pebbles, became powerful agents for grinding and wearing away the surface over which the ice passed. Preglacial ridges and hills were rubbed down, valleys were filled with the debris, and the surface features were changed entirely. The mixture of materials deposited by the glacier is known as boulder clay, till, glacial drift, or simply drift.

THE GLACIATIONS OF DEKALB COUNTY

There were at least three ice advances that reached DeKalb county and covered it wholly or in part. The first was probably the Illinoisan glacier, which covered the entire county. This glacier melted and somewhat normal conditions were restored, as is indicated by the thick soil formed from the material deposited by it. This is known as the Sangamon soil.

The drift left by this glacier was buried by another ice sheet, the Iowan. Later the early Wisconsin glacier covered about five-sixths of the county. In this glaciation two morainal ridges were left which cross the county in a northeastern and southwestern direction. These ridges belong to the general Bloomington morainic system. The northern, or outer, ridge is broken thru at places by branches of the Kishwaukee river and is about one hundred feet higher than the general level of the district to the west. The southern, or inner, ridge is narrower and not so high as the outer ridge. The average depth of the drift in the county is about 150 feet. The greatest thickness of the drift, as determined in making wells, is 260 feet. Many large granite boulders are found on the moraines. Some of these are as much as eight feet in diameter.

The glaciers that covered DeKalb county left a deposit called till, glacial drift, or boulder clay (a mixture of boulders, gravel, sand, silt, and clay), but this deposit does not form the soil material except in small areas. The rock flour

produced by the grinding action of the glaciers was reworked by the wind and deposited over practically all of the county to a depth of three to six feet. This loessial, or wind-blown, material has been transformed into soil by weathering and by the accumulation of organic matter, and now covers all the county except those places where it has been removed by erosion. There is little doubt but that this wind-blown material was fairly uniformly deposited over the exposed surface, but it has subsequently been removed in places by erosion, so that the boulder clay is exposed on some of the more rolling areas. The deposit is thicker on the Iowan glaciation than on the early Wisconsin, partly because of a deeper original deposit (3 to 6 feet), and partly because there has not been so much erosion on this less rolling area.

During the melting of the glacier the streams draining this area were frequently flooded, and the water carried large amounts of rather coarse material, such as gravel and sand. This was deposited in the valleys, partly filling them. Later the streams cut down thru the fill, leaving gravel terraces. This gravel was later covered with the fine material that now constitutes the soil. In the northeast township this flood water spread out over a large area, with the result that an extensive gravel plain was formed that reaches over into Kane and McHenry counties. Subsequent deposits of fine material on the surface of the gravel have aided in forming an excellent soil.

PHYSIOGRAPHY AND DRAINAGE

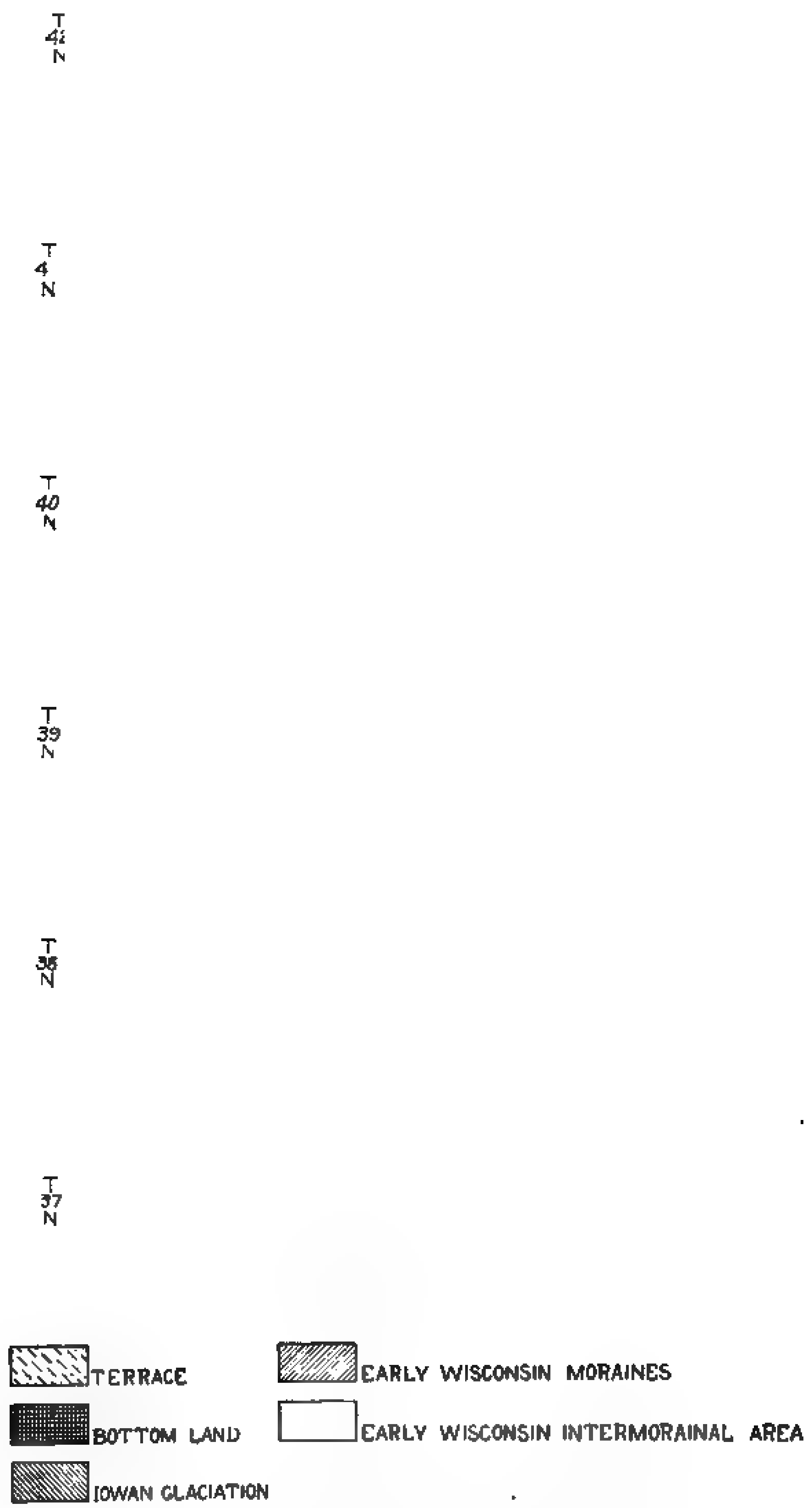
The county varies in topography from flat to slightly rolling. Even along the streams, hills do not exist to any extent. The principal variations are due to irregular deposition of glacial material. The moraines are characterized by an irregularly rounded, billowy topography, and they vary in width from three to six miles.

The southeast part of the county has a gradual slope to the Fox river, thru which this part is drained into the Illinois river. The northern two-thirds of the county is drained thru the Kishwaukee into the Rock river. Because of the flat character of the southeast part of the county, much tile draining has been done.

The altitudes of some places in DeKalb county are as follows: Carleton, 887 feet above sea level; Carleton Park, 855; Charter Grove, 875; Clair, 878; Cortland, 897; DeKalb, 886; Elva, 875; Esmond, 828; Fairdale, 787; Franks, 698; Genoa, 838; Hinckley, 740; Kingston, 795; Kirkland, 775; Lee, 939; Malta, 915; New Lebanon, 848; Rollo, 754; Sandwich, 667; Shabbona, 900; Shabbona Grove, 816; Somonauk, 690; Sycamore, 840; Van Buren, 740; Waterman, 820.

The highest altitude in the county, 955 feet, is found three miles north of Lee. Another high point occurs in the northwest part of Township 39 North, Range 5 East, which is about 940 feet.

In the terrace formation along the stream courses the soil is largely underlain by coarse material, such as sand and gravel, which provides favorable conditions for underdrainage.



MAP SHOWING THE DRAINAGE BASINS OF DEKALB COUNTY WITH MORAINAL, INTERMORAINAL, TERRACE, AND BOTTOM-LAND AREAS

SOIL TYPES

The soils of DeKalb county are divided into the following groups:

(a) Upland Prairie Soils, including the upland soils that have not been covered with forests and on which the luxuriant growth of prairie grasses has produced relatively large amounts of organic matter.

(b) Upland Timber Soils, including nearly all the upland areas that are now, or were formerly, covered with forests.

(c) Terrace Soils, including bench lands, or second bottom lands, formed by deposits from overloaded streams, and gravel outwash plains formed by broad sheets of water arising from the melting of the glaciers.

(d) Swamp and Bottom-Land Soils, including the overflow lands or flood plains along streams, the swamps, and the poorly drained lowlands.

Table 1 gives a list of the types of soil found in DeKalb county classified according to the groups described above. It also shows the area of each type in square miles and in acres, as well as the percentage of the total area. For example, it may be noted that the brown silt loam, or rolling prairie land, occupies more than four-fifths of the county. The accompanying map shows the location and boundary of each type of soil, even down to areas of a few acres.

For explanations concerning the classification of soils and the interpretation of the map and tables, the reader is referred to the first part of the Appendix.

TABLE 1.—SOIL TYPES OF DEKALB COUNTY, ILLINOIS

Soil type No.	Name of type	Area in square miles	Area in acres	Percent of total area
	(a) Upland Prairie Soils (700, 900, 1100)			
-26	Brown silt loam	516.82	330,765	81.68
-25	Black silt loam	7.96	5,094	1.26
-20	Black clay loam	.23	147	.04
-60	Brown sandy loam	.12	77	.02
-90	Gravelly loam	.12	77	.02
		525.25	336,160	83.02
	(b) Upland Timber Soils (700, 900, 1100)			
-34	Yellow-gray silt loam	41.46	26,534	6.55
-35	Yellow silt loam	.43	275	.07
-64	Yellow-gray sandy loam	.10	64	.01
		41.99	26,873	6.63
	(c) Terrace Soils (1500)			
1527	Brown silt loam over gravel	15.37	9,837	2.43
1525	Black silt loam	1.53	979	.24
1536	Yellow-gray silt loam over gravel	4.98	3,187	.79
1566	Brown sandy loam over gravel	.14	90	.02
		22.02	14,093	3.48
	(d) Swamp and Bottom-Land Soils (1400)			
1450	Black mixed loam	22.24	14,233	3.51
1401	Deep peat	2.02	1,293	.32
1402	Medium peat on clay	.04	26	.01
1454	Mixed loam	19.10	12,224	3.02
		43.40	27,776	6.86
	(e) Miscellaneous			
	Gravel pits	.04	26	.01
	Total	632.70	404,928	100.00

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INVOICE OF PLANT FOOD IN DE KALB COUNTY SOILS

SOIL ANALYSIS

The composition reported in the accompanying tables is, for the more extensive types, the average of several analyses. These analyses show that soils, like most things in nature, are variable; but for general purposes the average may be considered sufficient to characterize the soil type.

The chemical analysis of a soil, obtained by the methods here employed, gives the invoice of the total stock of the several plant-food materials actually present in the soil strata sampled and analyzed, but it should be understood that the rate of liberation, as explained in the Appendix (page 26), is governed by many factors.

For convenience in making practical application of the chemical analyses the results have been translated from the percentage basis and are presented here in terms of pounds per acre. In this, the assumption is made that for ordinary types a stratum of dry soil 6⅔ inches thick weighs 2,000,000 pounds. It is recognized that this value is only an approximation, but it is believed that it will suffice for the purposes intended. It is, of course, a simple matter to convert these figures back to the percentage basis in case one desires for any purpose to consider the information in that form.

THE SURFACE SOIL

In Table 2 are reported the amount of organic carbon (which serves as a measure of the organic matter), and the total quantities of nitrogen, phosphorus, sulfur, potassium, magnesium, and calcium contained in 2 million pounds of the surface soil (the plowed soil of an acre about 6⅔ inches deep) of each type in DeKalb county.

Because of the extreme variations frequently found within a given soil type with respect to the presence of limestone and acidity, no attempt is made to include in the tabulated results figures purporting to represent the average amounts of these substances present in the respective types. Such averages cannot give the farmer the specific information he needs regarding the lime requirements of a given field. Fortunately, however, very simple tests which can be made at home will furnish this important information, and these tests are described on pages 28 and 29 of the Appendix.

The variation among the different types of soil of DeKalb county with respect to the content of important plant-food elements is very marked. For example, the deep peat contains, in the plowed soil of an acre, nearly twenty-two times as much nitrogen as does the yellow-gray sandy loam. Comparing the deep peat with the most common type in the county, we find about five times as much nitrogen in it as in the brown silt loam, while on the other hand the brown silt loam contains more than thirteen times as much potassium as is found in the deep peat. The supply of phosphorus in the surface soil varies from 760 pounds per acre in the yellow-gray sandy loam to 2,540 pounds in the black silt loam. A sulfur content of 240 pounds per acre is found in the yellow-gray sandy loam, while in the deep peat there are 7,110 pounds of this element. The magnesium varies in the different types from 2,560 to 39,780 pounds, and the calcium content ranges from 4,080 to 83,210 pounds per acre.

TABLE 2.—PLANT FOOD IN THE SOILS OF DEKALB COUNTY, ILLINOIS: SURFACE SOIL
Average pounds per acre in 2 million pounds of surface soil (about 0-6⅔ inches)

Soil type No.	Soil type	Total organic carbon	Total nitrogen	Total phosphorus	Total sulfur	Total potassium	Total magnesium	Total calcium
	(a) Upland Prairie Soils (700, 900, 1100)							
726, 926, 1126	Brown silt loam	69 440	5 940	1 340	990	32 960	8 140	11 460
725, 925, 1125	Black silt loam	107 360	10 580	2 540	1 700	26 180	11 960	20 900
1120	Black clay loam	102 540	9 500	2 440	1 400	35 600	15 200	22 100
760, 960, 1160	Brown sandy loam	34 540	3 000	1 080	660	28 340	4 780	6 840
790, 990, 1190	Gravelly loam	43 180	4 260	1 360	980	25 660	39 780	71 700
	(b) Upland Timber Soils (700, 900, 1100)							
734, 934, 1134	Yellow-gray silt loam	27 970	2 540	1 070	580	33 380	6 440	7 990
735, 935, 1135	Yellow silt loam	26 800	2 540	880	640	44 480	6 720	7 460
764, 964	Yellow-gray sandy loam	20 300	1 500	760	240	23 180	2 560	4 520
	(c) Terrace Soils (1500)							
1527	Brown silt loam over gravel	71 480	6 650	1 540	1 170	29 010	9 110	13 660
1525	Black silt loam	122 700	11 680	2 420	2 160	28 600	10 220	22 620
1536	Yellow-gray silt loam over gravel	34 360	2 900	1 100	580	35 160	6 320	8 300
1566	Brown sandy loam over gravel	25 460	2 140	960	540	24 680	3 240	4 080
	(d) Swamp and Bottom-Land Soils (1400)							
1450	Black mixed loam	149 150	14 000	2 510	2 040	22 090	19 570	83 210
1401	Deep peat[1]	380 320	32 810	1 900	7 110	2 380	5 520	44 480
1402	Medium peat on clay[1]	342 140	27 320	1 410	3 070	7 520	4 690	24 750
1454	Mixed loam	55 380	4 460	1 660	900	30 200	6 420	10 420

LIMESTONE AND SOIL ACIDITY.—In connection with these tabulated data it should be explained that the figures on limestone content and soil acidity are omitted not because of any lack of importance of these factors, but rather because of the peculiar difficulty of presenting in general averages adequate information concerning the limestone requirement. The limestone requirement for soils is extremely variable. It may vary from farm to farm, and even from field to field. Therefore no attempt is made to include in these tables figures purporting to represent for the various types the limestone content or the soil acidity present. The need for limestone should be determined on every farm and for each field individually. Fortunately this can be easily done by the simple tests described in the Appendix to this report, pages 28 and 29.

[1]Amounts reported are for 1 million pounds of deep peat and medium peat.

It is important to note that some of the plant-food elements are present in very limited quantities as compared with crop requirements. Some simple computations are of interest in this connection. Assume, for example, that a four-field crop rotation of wheat, corn, oats, and clover yields 50 bushels of wheat per acre, 100 bushels of corn, 100 bushels of oats, and 4 tons of clover hay. These are high yields, but not impossible for they are sometimes obtained. It will be found that the most prevalent upland soil of DeKalb county, the brown silt loam, contains only enough total nitrogen in the plowed soil for the production of such yields to supply about twelve rotations.

TABLE 3.—PLANT FOOD IN THE SOILS OF DEKALB COUNTY, ILLINOIS: SUBSURFACE SOIL
Average pounds per acre in 4 million pounds of subsurface soil (about 6⅔–20 inches)

Soil type No.	Soil type	Total organic carbon	Total nitrogen	Total phosphorus	Total sulfur	Total potassium	Total magnesium	Total calcium
	(a) Upland Prairie Soils (700, 900, 1100)							
726, 926, 1126	Brown silt loam	65 360	6 000	1 900	1 140	68 100	21 510	21 800
725, 925, 1125	Black silt loam	83 200	8 240	3 080	1 720	59 960	25 080	32 960
1120	Black clay loam	65 360	6 360	3 200	1 240	78 440	28 920	34 080
760, 960, 1160	Brown sandy loam	29 760	2 960	1 640	680	59 720	14 640	11 160
	(b) Upland Timber Soils (700, 900, 1100)							
734, 934, 1134	Yellow-gray silt loam	18 640	2 120	1 950	630	71 990	21 690	15 590
735, 935, 1135	Yellow silt loam	20 040	2 400	1 720	720	108 800	25 320	14 640
764, 964	Yellow-gray sandy loam	17 680	1 320	1 400	400	49 160	5 840	10 320
	(c) Terrace Soils (1500)							
1527	Brown silt loam over gravel	58 060	5 500	2 140	1 240	66 940	21 300	25 000
1525	Black silt loam	70 600	6 920	3 080	1 800	65 040	21 040	27 680
1536	Yellow-gray silt loam over gravel	28 400	2 920	2 120	760	71 800	19 520	17 880
1566	Brown sandy loam over gravel	16 480	1 480	1 360	600	53 040	9 680	9 520
	(d) Swamp and Bottom-Land Soils (1400)							
1450	Black mixed loam	113 840	10 580	3 580	1 860	53 220	51 220	106 660
1401	Deep peat[1]	825 040	65 320	3 880	19 880	8 360	12 300	72 980
1402	Medium peat on clay[1]	372 720	32 060	1 940	4 240	24 340	12 160	38 560
1454	Mixed loam	70 280	5 680	2 920	1 360	60 040	13 080	16 480

LIMESTONE AND SOIL ACIDITY.—See note in Table 2.

[1]Amounts reported are for 2 million pounds of deep peat and medium peat.

With respect to phosphorus, the condition differs only in degree, this soil containing no more of that essential element than would be required for about eighteen crop rotations yielding at the rates suggested above. On the other hand the amount of potassium in the surface layer of this common soil type is sufficient for more than 25 centuries if only the grain is sold, or for nearly 400 years if the total crops should be removed from the land and nothing returned.

These general statements relating to the total quantities of these plant-food materials in the plowed soil of the most prevalent type in the county certainly emphasize the fact that the supplies of some of these necessary elements of fertility are extremely limited when measured by the needs of large crop yields for even one or two generations of people.

THE SUBSURFACE AND SUBSOIL

In Tables 3 and 4 are recorded the amounts of plant food in the subsurface and the subsoil of the different types. It should be remembered, however, that these supplies are of little value unless the top soil is kept rich. These tables

also show great stores of potassium in the prevailing types of soil but only limited amounts of nitrogen and phosphorus, in agreement with the data for the corresponding surface samples.

TABLE 4.—PLANT FOOD IN THE SOILS OF DEKALB COUNTY, ILLINOIS: SUBSOIL
Average pounds per acre in 6 million pounds of subsoil (about 20–40 inches)

Soil type No.	Soil type	Total organic carbon	Total nitrogen	Total phosphorus	Total sulfur	Total potassium	Total magnesium	Total calcium
	(a) Upland Prairie Soils (700, 900, 1100)							
726, 926, 1126	Brown silt loam	26 070	2 930	2 700	780	105 060	58 990	75 210
725, 925, 1125	Black silt loam	32 460	3 360	3 360	960	99 660	42 180	43 440
1120	Black clay loam	23 940	2 940	4 320	1 320	141 780	51 600	43 620
760, 960, 1160	Brown sandy loam	19 380	2 100	2 100	900	94 860	26 700	21 000
	(b) Upland Timber Soils (700, 900, 1100)							
734, 934, 1134	Yellow-gray silt loam	20 120	2 400	3 380	480	107 780	47 140	40 060
735, 935, 1135	Yellow silt loam	15 300	2 220	2 460	1 020	151 860	156 960	222 480
764, 964	Yellow-gray sandy loam	11 160	720	1 980	420	70 500	11 580	14 820
	(c) Terrace Soils (1500)							
1527	Brown silt loam over gravel	31 350	3 480	3 150	1 170	99 420	38 580	37 710
1525	Black silt loam	24 000	2 700	4 080	1 380	106 140	37 020	56 640
1536	Yellow-gray silt loam over gravel	21 660	2 520	3 900	720	96 000	39 900	33 600
1566	Brown sandy loam over gravel	16 020	1 380	1 680	660	81 480	13 560	17 100
	(d) Swamp and Bottom-Land Soils (1400)							
1450	Black mixed loam	88 980	7 620	5 700	1 890	84 360	102 810	187 710
1401	Deep peat[1]	801 900	57 420	5 220	24 690	27 600	22 620	83 610
1402	Medium peat on clay	285 060	20 520	3 120	6 660	112 200	49 500	64 440
1454	Mixed loam	41 400	3 660	3 900	1 320	96 780	26 160	28 200

LIMESTONE AND SOIL ACIDITY.—See note in Table 2.

[1]Amounts reported are for 3 million pounds of deep peat.

DESCRIPTION OF INDIVIDUAL SOIL TYPES

(a) UPLAND PRAIRIE SOILS

The upland prairie soils of DeKalb county cover 525.25 square miles, or more than four-fifths of the area of the county. They usually occupy the less rolling and comparatively level land, altho some exceptions to this are to be found. These prairie soils are dark in color owing to their relatively high organic-matter content. This land was originally covered with prairie grasses, the partially decayed roots of which have been the principal source of the organic matter. The flat, poorly drained areas contain the greatest amounts of organic matter, owing to the more luxuriant growth of grasses in such situations and to the excessive soil moisture which has provided conditions more favorable for their preservation.

Brown Silt Loam (726, 926, 1126)

Brown silt loam is the most extensive type in DeKalb county, covering 516.82 square miles, or more than 80 percent of the area of the county. It is found on the more level land, a considerable portion of which needs artificial drainage. While the type is primarily prairie, yet in some sections timber has extended over it to a slight extent. The trees found on the timbered areas are usually bur oak, wild cherry, and elm, but their occupation of the soil has not been sufficiently long to change its character to any great extent. The type, however, may include some small areas of yellow-gray silt loam (—34) too small to be shown on the map.

The surface soil, 0 to 6⅔ inches, is a brown silt loam varying from a yellowish brown on the more rolling areas to a dark brown or black on the more nearly level and poorly drained tracts. In physical composition it varies to some extent, but it normally contains from 50 to 75 percent of the different grades of silt. In the low areas the proportion of clay is usually higher than on the more rolling parts, where a perceptible amount of sand may occur. On account of of the varied topography of the type, the organic-matter content in the surface soil is rather variable, but it averages about 6 percent, or 60 tons per acre. In the more rolling phase, small patches are found which have been eroded to such an extent that the yellow subsoil appears. These areas are usually not large enough to be shown on the map as a separate type.

The natural subsurface is represented by a stratum varying from 5 to 16 inches in thickness. This variation is due to erosion, the stratum being thinner on the more rolling areas. In physical composition the subsurface varies about the same as the surface soil, but on the less rolling areas it normally contains a larger percentage of clay, while on the more rolling areas the sand content becomes greater. The organic-matter content varies with topography in the same manner as the surface, being greater on the more level land. It averages about 2.7 percent, or 54 tons per acre in a stratum 13⅓ inches thick. In color the subsurface varies from a dark brown or almost black to a light yellowish brown, which becomes lighter with increasing depth.

The natural subsoil begins 11 to 22 inches beneath the surface and extends to an indefinite depth. It varies from a yellow to a drabbish yellow, clayey

material, sometimes composed wholly or in part of boulder clay or drift. The stratum sampled (20 to 40 inches) contains about .7 percent of organic matter. In some of the flat areas that are not subject to erosion, but where material has washed in from the higher surrounding land, the subsoil to a depth of 40 inches does not reach the boulder clay.

Each of the three strata is pervious to water, so that drainage takes place with little difficulty.

Management.—When the virgin brown silt loam was first cropped, the soil was in fine tilth, worked easily, and much less effort was required to produce a good seed bed than is now the case where the soil has been heavily cropped for many years and where the organic matter has not been maintained. Unless the moisture content is very favorable, the soil under this latter condition plows up cloddy, and the clods may remain all season. Much plant food will be locked up in them, and the best results cannot be obtained. The remedy for poor tilth is to increase the amount of organic matter by turning under every available form of vegetable matter, such as farm manure, corn stalks, straw, clover, stubble, and even weeds. The addition of fresh organic matter is not only of great value in improving the physical condition of this type of soil, but it is equally important because of its nitrogen content, and also because of its power, as it decays, to liberate potassium from the inexhaustible supply in the minerals of the soil and phosphorus from the phosphate contained in or applied to the soil. The deficiency of organic matter in the soil is shown by the way fall-plowed land runs together during the winter. In the spring, fall-plowed land should be disked early and deep for the purpose of conserving moisture, raising the temperature, and making plant food available.

For permanent, profitable systems of farming on brown silt loam, phosphorus should usually be applied liberally, and sufficient organic matter should be provided to furnish the necessary amount of nitrogen. While the subsoil usually contains an abundance of carbonates, on the prevailing phase of the type limestone is becoming deficient in the upper strata so that an application of 1 to 2 tons of limestone per acre is advisable, and in the preparation of the land for alfalfa heavier applications are justifiable. To enrich the soil in phosphorus, ½ to 1 ton of finely ground rock phosphate per acre should be applied about every four years. This treatment, along with the judicious return to the land of organic manures made from a good rotation, will not only maintain but will increase the fertility of this soil.

If grain farming is practiced, a good rotation to be suggested might be wheat, corn, oats, and clover, with an extra seeding of clover (preferably sweet clover) as a cover crop in the wheat, to be plowed under late in the fall or in the following spring for corn. Most of the crop residues, including the clover chaff from the seed crops, should also be plowed under. In live-stock farming, this rotation may be extended to five or six years by seeding both timothy and clover with the oats, and pasturing one or two years. In either the grain or the live-stock system, alfalfa may be grown on a fifth field and moved every rotation, the hay being fed or sold. Other suggestions for various crop rotation programs will be found in the Appendix (page 34).

For an account of field experiments on this type of soil the reader is referred to page 37 of the Supplement.

Black Silt Loam (725, 925, 1125)

Black silt loam is confined to small areas in depressions and along streams. It is generally scattered over the county and occurs in areas similar in location to those occupied by black clay loam in central Illinois. The type covers 5,094 acres, or 1.26 percent of the area of the county.

The surface soil, 0 to 6⅔ inches, is a black, granular, silt to clayey silt loam. It contains normally about 9.2 percent of organic matter, or 92 tons per acre, altho in certain small areas the organic-matter content may vary from that of brown silt loam to that of muck.

The natural subsurface is represented by a stratum about 12 inches thick, and is a black silt loam passing into a drab clayey silt at 18 to 20 inches in depth. The organic-matter content of the stratum sampled (6⅔ to 20 inches) is about 3.6 percent, or 72 tons per acre.

The subsoil is a drab or yellowish drab clayey silt or silty clay, sometimes containing pebbles. All strata are readily pervious to water.

Management.—The first consideration in the management of this type is drainage. The content of nitrogen and phosphorus is high, and no attention need be given these elements for some time if a good rotation is practiced. The limestone is often low, and applications may soon be necessary to produce the best results with legumes.

Alkali spots are common in this type. Applications of 150 to 200 pounds of potash salts per acre, or of several tons of coarse stable manure, or sweet clover turned under, will usually be effective in counteracting the effect of the alkali. These spots should be thoroughly tiled, as the leaching out of the alkali is about the only permanent remedy for removing it.

Black Clay Loam (1120)

The areas of black clay loam are about twelve in number and the largest does not cover more than 40 acres. The total area covered by this type is about 147 acres. A small area occurring on the terrace is included with this upland type.

The surface soil, 0 to 6⅔ inches, is a black, plastic, granular clay loam containing about 8.8 percent of organic matter, or 88 tons per acre.

The subsurface is a black clay loam with about 2.8 percent of organic matter, or 56 tons per acre.

The subsoil is a drab to yellowish drab silty clay or clayey silt.

Management.—Drainage is the first requirement of this type. It is abundantly supplied with plant food, but is somewhat acid and may need limestone for legumes, altho there are areas where alkali is so abundant as to be injurious. The treatment for alkali is the same as that described for the alkali spots in the preceding type.

Brown Sandy Loam (760, 960, 1160)

Brown sandy loam occurs in a few small isolated areas covering in total about 77 acres. It has been formed by sand blown from the bottom land onto the adjoining upland.

The surface soil, 0 to 6⅔ inches, is a brown sandy loam containing about 3 percent of organic matter, or 30 tons per acre.

The natural subsurface, consisting of a stratum about 9 inches thick, is a brown sandy loam. The stratum as sampled (6⅔ to 20 inches), contains about 1.3 percent of organic matter.

The subsoil is a sandy silt or a silty sand of a yellow color.

Management.—The type is fairly well supplied with phosphorus and at present the most important consideration is the maintenance of the organic-matter and nitrogen contents. The recommendation, therefore, is the same as that suggested for brown silt loam.

Gravelly Loam (790, 990, 1190)

Gravelly loam occurs in several small spots in various parts of the county and covers as a total about 77 acres. An eskerlike gravel ridge about one mile in length, in Sections 5 and 6, Township 38 North, Range 5 East, is the largest area. The type is variable and of little agricultural value.

(b) UPLAND TIMBER SOILS

The upland timber soils usually occur along streams, altho two exceptions are found in DeKalb county where forests exist remote from streams. Timber soils are characterized by a yellow, yellowish gray, or gray color, due to their low organic-matter content resulting from the long-continued growth of forest trees. As the forests invaded the prairies, two effects were produced: (1) the shade from the trees prevented the growth of prairie grasses, the roots of which are mainly responsible for the large amount of organic matter in prairie soils; (2) the trees themselves added very little organic matter to the soil, for the leaves and fallen branches either decayed completely or were burned by forest fires. As a result the timber soils contain a relatively low percentage of organic matter.

The total area of upland timber soils in DeKalb county is 41.99 square miles.

Yellow-Gray Silt Loam (734, 934, 1134)

Yellow-gray silt loam occurs in the outer timber belts along streams, and in the less rolling of the timbered morainal areas. The type covers 41.46 square miles, or 6.55 percent of the entire area of DeKalb county. In topography, it is sufficiently rolling for good surface drainage, without much tendency to wash if proper care is taken. The effect of the prevailing southwesterly winds may be seen in the distribution of the type. It is nearly all on the north and east side of the Kishwaukee river. The wind, as well as prairie fires, controlled such distribution.

The surface soil, 0 to 6⅔ inches, is a yellow, yellowish gray, gray, or brownish gray silt loam, having a floury feel. The more nearly level areas incline toward a grayish color, while the more rolling phase of the type has a yellow or brownish yellow color. As the type approaches the brown silt loam (—26), the organic matter increases until it grades into that type. The organic-matter content averages 2.4 percent, or 24 tons per acre, and is somewhat lower in the Iowan glaciation than in the early Wisconsin.

The natural subsurface soil is represented by a stratum from 3 to 10 inches thick. It is usually a gray, grayish yellow, or yellow silt loam, somewhat pulverulent, but becoming more coherent and plastic with increasing depth. The subsurface as sampled (6⅔ to 20 inches) contains about .8 percent of organic matter, or 16 tons per acre in four million pounds of soil.

The subsoil is a yellow or mottled grayish yellow, clayey silt or silty clay, somewhat plastic when wet, but friable when only moist, and pervious to water.

Owing to the removal by erosion of part of the loessial material, glacial drift is sometimes encountered at a depth of less than 40 inches. The glacial drift may be locally a very gravelly deposit, but usually it is a slightly gravelly clay.

Management.—In the management of this yellow-gray silt loam, one of the most essential points is the maintaining or the increasing of organic matter. This is necessary in order to supply nitrogen, to liberate mineral plant food, to give better tilth, to prevent "running together," and, on some of the more rolling phases, to prevent washing.

Another essential is that the acidity of the soil be neutralized by the application of ground limestone, so that clover, alfalfa, and other legumes may be grown more successfully. The initial application may well be 2 to 4 tons per acre, after which a sufficient amount may be applied to keep the soil in good condition for growing legumes. Since the soil is poor in phosphorus, this element should be supplied, preferably in connection with farm manure or clover plowed under. In permanent systems of farming, finely ground natural rock phosphate will be found the most economical form in which to supply the phosphorus.

Among the crops deserving of special consideration for this type of soil are sweet clover and alfalfa. On soil deficient in organic matter sweet clover grows better than almost any other legume, and the fact that it is a very deep-rooting plant makes it of value for opening up the subsoil, increasing the organic matter, and preventing washing. Slopes that have been made worthless by washing may be made profitable as pasture by growing sweet clover. The blue grass of pastures may well be supplemented by sweet clover and alfalfa, and a larger growth obtained, because the legumes provide the necessary nitrogen for the blue grass.

To get alfalfa well started requires the liberal use of limestone, thoro inoculation with nitrogen-fixing bacteria, and a moderate application of farm manure. If manure is not available, it is well to apply about 500 pounds per acre of acid phosphate or steamed bone meal, mix it with the soil, by disking if possible, and then plow it under. The limestone (about 4 or 5 tons per acre) should be applied after plowing and should be mixed with the surface soil in the preparation of the seed bed. The special purpose of this treatment is to insure for the alfalfa a vigorous early growth.

See page 50 of the Supplement for an account of field experiments on this type of soil.

Yellow Silt Loam (735, 935, 1135)

Yellow silt loam covers only 275 acres in DeKalb county. It occurs as hilly and badly eroded land on the inner timber belts adjacent to the stream valleys, usually only in narrow, irregular strips. In topography it is very

rolling, and in most places so badly broken that it should not be cultivated because of the danger of injury from washing.

The surface soil, 0 to 6⅔ inches, is a yellow or grayish yellow, pulverulent silt loam. It varies greatly in color and texture, owing to recent washing. In places the natural subsoil may be exposed. This exposure gives the surface a decidedly yellow color. When freshly plowed the soil appears yellow or brownish yellow, but when it becomes dry after a rain, it is of a grayish color. In some places the surface soil is formed from glacial drift, but this is only on very limited areas and on the steepest slopes. The organic-matter content averages 2.3 percent, or 23 tons per acre.

The natural subsurface varies from a yellow silt loam to a yellow clayey silt loam, and on the slopes that have been subjected to recent erosion, may consist of glacial drift. The stratum as sampled (6⅔ to 20 inches) contains about .8 percent of organic matter, or 16 tons per acre.

The natural subsoil is composed almost entirely of yellow boulder clay. Where recent erosion has taken place, all strata may be boulder clay.

Management.—One of the best uses to which this type can be put is permanent pasture. As a rule it cannot be satisfactorily cropped in ordinary rotations because it is so hilly, but it may be used very successfully for long rotations with pasture or meadow much of the time. Where both the surface and subsurface are acid, ground limestone may well be used for legumes in the rotation or even as a top dressing to encourage their growth in pastures. Where this type has been long cultivated and thus exposed to surface washing, it is particularly deficient in nitrogen. Among the crops that are perhaps best adapted to this type sweet clover and alfalfa should be mentioned. Suggestions concerning their culture have already been given in connection with the discussion of yellow-gray silt loam (page 15).

Yellow-Gray Sandy Loam (764, 964, 1164)

Yellow-gray sandy loam occurs principally in the northern part of the county as a few small areas, which make a total of 64 acres.

The surface soil, 0 to 6⅔ inches, is a yellow or grayish yellow sandy loam usually containing some gravel; in a few instances small patches of gravelly loam occur. The soil is made largely from sandy till. The organic-matter content is about 1.8 percent, or 18 tons per acre.

The natural subsurface stratum varies from 3 to 10 inches in thickness. It is of a lighter color than the surface soil owing to the smaller amount of organic matter present. This stratum is usually formed from gravelly, sandy till, but it often contains a considerable proportion of clay.

The subsoil varies from gravelly till to sand.

Management.—For the improvement of this type, the addition of organic matter and nitrogen is essential. Limestone should also be applied liberally for the best results with legumes. Where the subsurface and subsoil are very compact, owing to the presence of silt and clay, sweet clover should be grown to loosen the subsoil.

(c) TERRACE SOILS

The terrace soils in DeKalb county usually occur along streams. They were formed at a time when the streams, owing to melting glacier ice, were much larger than they are at present, and carried large amounts of coarse material such as sand and gravel. Upon any decrease in their velocity, these overloaded streams would deposit debris along their courses; and this resulted in the partial filling of the valley and the forming of what are now the terraces, bench lands, or second bottom lands. Finer material later deposited over this sand and gravel forms the present soil.

When the streams again reached their normal size after the glacier had melted, they began cutting down thru the deposit, and they are now so low that the terraces, or benches, do not overflow. A gravel outwash plain occurs in the northeastern part of Township 42 North, Range 5 East, that was formed when the shallow water of the melting ice spread over a large level area and deposited sand and gravel which was later covered with a fine material well adapted to forming a good soil.

Brown Silt Loam over Gravel (1527)

Brown silt loam over gravel is found principally in the northern half of the county along the South Branch of the Kishwaukee river, occurring almost entirely on the south and west sides of this stream. Another area is found in the northeast part of the county along the county line. This is a gravel outwash plain. Doubtless at one time some of the water of Coon creek valley flowed west across Sections 15 and 22, Township 42 North, Range 5 East, into the South Branch of the Kishwaukee. The type covers an area of 9,837 acres, or nearly 2.5 percent of the county. The depth to gravel varies from 30 to more than 50 inches, the average being a little more than 40 inches.

The surface soil, 0 to 6⅔ inches, is a brown silt loam varying to black. In physical composition it varies from a clayey silt loam to a loam or even to a sandy loam in areas too small to be shown on the map. It usually contains a perceptible amount of sand. The topography is generally flat, but slight undulations may occur that were probably produced by the channels of the flooded streams. The surface stratum contains approximately 6.2 percent of organic matter, or 62 tons per acre, the amount varying from 47 to 77 tons per acre.

The natural subsurface varies from 7 to 16 inches in thickness. The stratum sampled (6⅔ to 20 inches) contains about 2.5 percent of organic matter, or 50 tons per acre. In physical composition it is about the same as the surface soil.

The subsoil is a yellow to drabbish mottled yellow silt loam, with some gravel appearing in the deeper subsoil.

All strata are pervious to water, so that drainage is practically perfect where the water table is sufficiently low. The gravel is so far from the surface that crops do well even in years of some drouth. This is one of the best of the terrace types.

Management.—In the improvement of this type limestone, phosphorus, and organic matter should be provided in about the same amounts as those recommended for the brown silt loam of the prairie (—26). However, because of the

greater porosity of this type, applications of phosphorus are likely to occupy third place in immediate effect.

Black Silt Loam (1525)

Black silt loam occurs only in the northern part of the county in Township 42 North along the Kishwaukee, and covers 979 acres. The topography is flat.

The surface soil, 0 to 6⅔ inches, is a black granular silt loam, locally becoming a clayey silt loam. This stratum contains about 10.6 percent of organic matter, or 106 tons per acre.

The natural subsurface soil is from 10 to 14 inches in thickness. The organic-matter content of the stratum sampled (6⅔ to 20 inches) is about 3 percent.

The subsoil is a pale yellow to a drabbish yellow silt or clayey silt. It contains about .7 percent of organic matter.

Management.—The strata are pervious to water and drainage takes place readily by means of tile. Aside from drainage, good cultivation is about the only requirement at present, since the plant-food elements are usually abundant. Some alkali areas occur which may be greatly improved by turning under sweet clover.

Yellow-Gray Silt Loam over Gravel (1536)

With the exception of two small areas near Sandwich, yellow-gray silt loam over gravel is found in the northern half of the county, chiefly along the east and north sides of the Kishwaukee river. The type covers altogether 3,187 acres.

The surface soil, 0 to 6⅔ inches, is a grayish or yellowish gray silt loam, containing about 3 percent of organic matter, or 30 tons per acre. It varies in physical composition from a silt loam to a loam, and in small areas it may approach even a sandy loam.

The natural subsurface, comprizing a stratum from 6 to 10 inches thick, is a yellow to grayish yellow silt loam. The stratum sampled (6⅔ to 20 inches) contains about 1.3 percent of organic matter.

The subsoil is a clayey silt of a yellow or slightly grayish yellow color. Gravel occurs at a depth of 38 to 48 inches.

Management.—The low content of organic matter and nitrogen calls for the liberal use of leguminous crops, but to make conditions most favorable for their growth limestone should be applied at the rate of about 2 tons per acre. Phosphorus is likewise low and this element should be replenished by the use of rock phosphate.

Brown Sandy Loam over Gravel (1566)

Brown sandy loam over gravel occurs in a few small areas in the northeastern part of the county, and covers a total of 90 acres. The gravel lies from 40 to 50 inches below the surface.

The surface soil, 0 to 6⅔ inches, is a rather light colored brown sandy loam containing about 2.2 percent of organic matter, or 22 tons per acre.

The natural subsurface soil is represented by a stratum 4 to 9 inches thick. The organic-matter content of the stratum sampled (6⅔ to 20 inches) is about .7 percent.

The subsoil is a yellow sand to silty sand. Gravel occurs at 40 to 50 inches.

Management.—This type should be managed the same as the brown sandy loam of the upland (see page 14).

(d) SWAMP AND BOTTOM-LAND SOILS

In the group designated as swamp and bottom-land soils are included the overflow land or flood plains along streams, the swamps, and the poorly drained lowlands. The four types recognized as belonging to this group make up nearly 7 percent of the area of DeKalb county.

Black Mixed Loam (1450)

Black mixed loam occurs in a large number of small, isolated areas all over the county. These occur principally in low places that were formerly swamps, ponds, or sloughs. The largest areas of this type are found in the northeast part of the county. The total area of this soil is 22.24 square miles, or 14,233 acres.

The surface soil, 0 to 6⅔ inches, varies widely in its physical composition. For example, on a single ten acres, borings of shallow peat, black sandy loam, peaty loam, and gravelly loam were found. The samples taken to represent the type contained approximately 12.9 percent of organic matter.

The natural subsurface varies in thickness from 8 to 24 inches. In physical composition, it varies in somewhat the same manner as the surface, except that it is generally lighter in color. The organic-matter content of the stratum sampled (6⅔ to 20 inches) is about 9.8 percent.

The subsoil is more uniform than the other strata and is usually a gray, drab, or yellow silty or clayey material.

Management.—Drainage is the first requirement and since all strata are pervious, drainage is a comparatively easy matter if a sufficient outlet can be obtained. All varieties of the type are very rich in nitrogen and elements of plant food generally, with possibly the exception of potassium in the more peaty phase of the type.

Deep Peat (1401)

Deep peat is well distributed over the county, but usually occurs only in small areas. The total area of the type is 1,293 acres.

The surface soil, 0 to 6⅔ inches, is a brown to black peat, containing about 65.6 percent of organic matter, or 328 tons per acre.

The subsurface stratum is about 13 inches thick and is similar to the surface except that it contains more organic matter, about 71.1 percent.

The subsoil contains, in the area sampled, about 46 percent of organic matter.

Management.—Drainage is of first importance with this type, but in many cases is very difficult to secure. Tile cannot be laid to the best advantage in peat on account of irregular settling and the consequent displacement of the line. This difficulty may be partly overcome by placing the tiles upon boards laid in the bottom of the ditch.

Where thoro drainage can be provided, either by the above method, by open ditches, or by laying tiles deep enough to secure a solid bed for them, very marked improvement can be made in the productive power of deep peat by the liberal use of potassium, which is by far the most deficient element. The type is well supplied with phosphorus.

For an account of field experiments on deep peat the reader is referred to page 53 of the Supplement.

Medium Peat on Clay (1402)

Medium peat on clay is found in only a few small areas in the northern half of the county and covers an area of but 26 acres.

The surface soil, 0 to 6⅔ inches, is a brown to black peat with about 59 percent of organic matter.

The subsurface contains about 32 percent of organic matter.

The clay subsoil contains about 8.2 percent of organic matter.

Management.—If this type is not productive when well drained, it may, in some cases where the clay is not too deep, be improved by extra deep plowing. By this process clayey material, with its higher potassium content, is incorporated with the peat. When this cannot be done, the use of coarse manure or of commercial potassium is advised.

Mixed Loam (1454)

Mixed loam occurs as irregular bottoms along the streams, practically all of which overflow. The total area covered is 12,224 acres, or about 3 percent of the area of the county.

The surface soil, 0 to 6⅔ inches, is a mixed loam varying from a black silty clay loam to a brown sandy loam. Occasionally small patches of peat are found. The sample taken contained about 4.8 percent of organic matter, or 48 tons per acre.

The subsurface is a brown mixed loam varying in physical composition the same as the surface. It contains, according to the sample, about 3 percent of organic matter.

The subsoil is a brownish silt to sandy loam, becoming lighter with increasing depth.

Management.—In the management of this type, good cultivation is about the only thing to be considered.

APPENDIX

EXPLANATIONS FOR INTERPRETING THE SOIL SURVEY

CLASSIFICATION OF SOILS

In order to intelligently interpret the soil maps, the reader must understand something of the method of soil classification upon which the survey is based. Without going far into details the following paragraphs are intended to furnish a brief explanation of the general plan of classification here used.

The unit in the soil survey is the soil type, and each type possesses more or less definite characteristics. The line of separation between adjoining types is usually distinct, altho sometimes one type grades into another so gradually that it is very difficult to draw the line between them. In such exceptional cases, some slight variation in the location of soil-type boundaries is unavoidable.

In establishing soil types several factors must be taken into account. These are: (1) the geological origin of the soil, whether residual, cumulose, glacial, eolial, alluvial, or colluvial; (2) the topography, or lay of the land; (3) the native vegetation, as prairie grasses or forest; (4) the depth and the character of the surface, the subsurface, and the subsoil, as to the percentages of gravel, sand, silt, clay, and organic matter which they contain, their porosity, granulation, friability, plasticity, color, etc.; (5) the natural drainage; (6) the agricultural value, based upon its natural productiveness; (7) the ultimate chemical composition and reaction.

Great Soil Areas in Illinois.—On the basis of the first of the above mentioned factors, namely, the geological origin, the state of Illinois has been divided into seventeen great soil areas with respect to their geological formation. The names of these areas are given in the following list along with their corresponding index numbers, the use of which is explained below. For the location of these geological areas, the reader is referred to the general map published in Bulletins 123 and 193.

000 *Residual,* soils formed in place thru disintegration of rocks, and also rock outcrop
100 *Unglaciated,* comprizing three areas, the largest being in the south end of the state
200 *Illinoisan moraines,* including the moraines of the Illinoisan glaciations
300 *Lower Illinoisan glaciation,* covering nearly the south third of the state
400 *Middle Illinoisan glaciation,* covering about a dozen counties in the west-central part of the state
500 *Upper Illinoisan glaciation,* covering about fourteen counties northwest of the middle Illinoisan glaciation
600 *Pre-Iowan glaciation,* but now believed to be part of the upper Illinoisan
700 *Iowan glaciation,* lying in the central northern end of the state
800 *Deep loess areas,* including a zone a few miles wide along the Wabash, Illinois, and Mississippi rivers
900 *Early Wisconsin moraines,* including the moraines of the early Wisconsin glaciation
1000 *Late Wisconsin moraines,* including the moraines of the late Wisconsin glaciation
1100 *Early Wisconsin glaciation,* covering the greater part of the northeast quarter of the state
1200 *Late Wisconsin glaciation,* lying in the northeast corner of the state
1300 *Old river-bottom and swamp lands,* found in the older or Illinoisan glaciation
1400 *Late river-bottom and swamp lands,* those of the Wisconsin and Iowan glaciations
1500 *Terraces,* bench or second bottom lands, and gravel outwash plains
1600 *Lacustrine deposits,* formed by Lake Chicago, the enlarged glacial Lake Michigan

Mechanical Composition of Soils.—The mechanical composition, or the texture, is a most important feature in characterizing a soil. The texture depends upon the relative proportions of the following physical constituents:

Organic matter: undecomposed and partially decayed vegetable material
Inorganic matter: clay, silt, fine sand, sand, gravel, stones

Classes of Soils.—Based upon the relative proportion of the various constituents mentioned above, soils may be grouped into a number of well recognized classes. Following is a list of these classes, arranged according to their index numbers, the use of which is explained below:

Index Number Limits	Class Names
0 to 9	Peats
10 to 12	Peaty loams
13 to 14	Mucks
15 to 19	Clays
20 to 24	Clay loams
25 to 49	Silt loams
50 to 59	Loams
60 to 79	Sandy loams
80 to 89	Sands
90 to 94	Gravelly loams
95 to 97	Gravels
98	Stony loams
99	Rock outcrop

Naming and Numbering Soil Types.—The naming of soil types has been the subject of much discussion, and practice varies considerably in this matter. In this soil survey of Illinois a system of classification and naming has been adopted which is based upon the various considerations presented in the preceding paragraphs.

After texture, one of the most striking characteristics of a soil is the color. Therefore, in the naming of soils in Illinois, a combination of color and texture, together with other descriptive terms when necessary, has been adopted so that the name in itself carries a definite description of a given soil type; as for example, "gray silt loam on tight clay," or "brown silt loam over gravel." The use of the prepositions *on* and *over* serves to indicate the presence of certain substrata. When the surface soil is underlain with material such as sand, gravel, or rock, the word *over* is used if this material lies at a depth greater than 30 inches; if it is less than 30 inches, the word *on* is used.

For further identification of soil types a system of numbering, resembling somewhat the Dewey library system, has been adopted whereby each soil type is assigned a certain number. This number indicates at once the geological origin of the soil as well as its physical description. The digits of the order of hundreds represent the geological area where the soil is found, beginning with 000, the residual, followed by 100, the unglaciated, and the rest of the series in the order of the enumeration presented in the paragraph above headed *Great Soil Areas in Illinois*. The digits of the orders of units and tens represent the various kinds of soil such as are enumerated above in the list of soil classes. Certain modifications are designated in this system by a figure placed at the right of the decimal point. To illustrate the working of this numbering system, suppose a soil type bears the number 726.5. The number 7 indicates that this soil occurs in the Iowan glaciation, the 26 that it is a brown silt loam, and the .5 that rock

is found less than 30 inches below the surface. These numbers are especially useful in designating small areas on the map and as a check in reading the colors.

A complete list of the soil types occurring in each county, along with their corresponding type numbers and the area covered by each type, will be found in the respective county soil reports.

SOIL SURVEY METHODS

Mapping the Soil Types.—In conducting the soil survey, the county constitutes the unit of working area. In order that the survey be thoroly trustworthy it is necessary that careful, well-trained men be employed to do the mapping. The work is prosecuted to the best advantage by working in parties of from two to four. Only such men are placed in charge of these parties as are thoroly experienced in the work and have shown themselves to be especially well qualified in training and ability.

The men must be able to keep their location exactly and to recognize the different soil types, with their principal variations and limits, and they must show these upon the maps correctly. A definite system is employed in checking up this work. As an illustration, one man will survey and map a strip 80 rods or 160 rods wide and any convenient length, while his associate will work independently on another strip adjoining this area, and if the work is correctly done the soil-type boundaries will match up on the line between the two strips.

An accurate base map for field use is absolutely necessary for soil mapping. The base maps are prepared on a scale of one inch to the mile, the official data of the original or subsequent land survey being used as a basis in their construction. Each surveyor is provided with one of these base maps, which he carries with him in the field; and the soil-type boundaries, together with the streams, roads, railroads, canals, and town sites are placed in their proper locations upon the map while the mapper is on the area. Each section, or square mile, is divided into 40-acre plots on the map, and the surveyor must inspect every ten acres and determine the type or types of soil thereon. The different types are indicated on the map by different colors, pencils for this purpose being carried in the field.

A small auger 40 inches long forms for each man an invaluable tool with which he can quickly secure samples of the different strata for inspection. An extension for making the auger 80 inches long is taken by each party, so that any peculiarity of the deeper subsoil layers may be studied. Each man carries a compass to aid in keeping directions. Distances along roads are measured by a speedometer or by some other measuring device, while distances in the field away from the roads are determined by pacing, an art in which the men become expert by practice. The soil boundaries can thus be located with as high a degree of accuracy as can be indicated by pencil on the scale of one inch to the mile.

Sampling for Analysis.—After all the soil types of a county have been located and mapped, samples representative of the different types are collected for chemical analysis. For this purpose usually three strata are sampled; namely, the surface (0 to 6⅔ inches), the subsurface (6⅔ to 20 inches), and the subsoil

(20 to 40 inches). These strata correspond approximately, in the common kinds of soil, to 2,000,000 pounds of dry soil per acre in the surface layer, and to two times and three times this quantity in the subsurface and the subsoil, respectively. This is, of course, a purely arbitrary division, very useful in arriving at a knowledge of the quantity and the distribution of plant food in the soil, but it should be noted that these strata do not necessarily coincide with the natural strata as they actually exist in the soil, and which are referred to in describing the soil types.

By this system of sampling we have represented separately three zones for plant feeding. The surface layer includes at least as much soil as is ordinarily turned with the plow. This is the part with which the farm manure, limestone, phosphate, or other fertilizer applied in soil improvement is incorporated, and which must be depended upon in large part to furnish the necessary plant food for the production of crops. A rich subsoil has little or no value if it lies beneath a worn-out surface, but if the fertility of the surface soil is maintained at a high point, then the strong vigorous plants will have power to secure more plant food from the subsurface and subsoil.

PRINCIPLES OF SOIL FERTILITY

Probably no agricultural fact is more generally known by farmers and landowners than that soils differ in productive power. Even tho plowed alike and at the same time, prepared the same way, planted the same day with the same kind of seed, and cultivated alike, watered by the same rains and warmed by the same sun, nevertheless the best acre may produce twice as large a crop as the poorest acre on the same farm, if not, indeed, in the same field; and the fact should be repeated and emphasized that with the normal rainfall of Illinois the productive power of the land depends primarily upon the stock of plant food contained in the soil and upon the rate at which it is liberated, just as the success of the merchant depends primarily upon his stock of goods and the rapidity of sales. In both cases the stock of any commodity must be increased or renewed whenever the supply of such commodity becomes so depleted as to limit the success of the business, whether on the farm or in the store.

CROP REQUIREMENTS

Ten different elements of plant food are essential for the growth and formation of every plant. These elements are: *carbon, oxygen, hydrogen, nitrogen, phosphorus, sulfur, potassium, magnesium, calcium, and iron;* and they are represented by the chemical symbols: C, O, H, N, P, S, K, Mg, Ca, and Fe. Some seasons in central Illinois are sufficiently favorable to allow the production of at least 50 bushels of wheat per acre, 100 bushels of corn, 100 bushels of oats, and 4 tons of clover hay. When such crops, growing under favorable climatic and cultural conditions and uninjured by disease or insect pests, are not produced the failure is due to unfavorable soil condition, which may result from poor drainage, poor physical condition, or from an actual deficiency of plant food.

Table A shows the plant-food requirements of some of our most common field crops with respect to the seven elements furnished by the soil. The figures show the weight in pounds of the various elements contained in a bushel or in a

TABLE A.—PLANT FOOD IN WHEAT, CORN, OATS AND CLOVER

Produce		Nitrogen	Phosphorus	Sulfur	Potassium	Magnesium	Calcium	Iron
Kind	Amount							
		lbs.	*lbs.*	*lbs.*	*lbs.*	*lbs.*	*lbs.*	*lbs.*
Wheat, grain......	1 bu.	1.42	.24	.10	.26	.08	.02	.01
Wheat, straw.....	1 ton	10.00	1.60	2.70	18.00	1.60	3.80	.60
Corn, grain.......	1 bu.	1.00	.17	.08	.19	.07	.01	.01
Corn stover.......	1 ton	16.00	2.00	2.42	17.33	3.33	7.00	1.60
Corn cobs........	1 ton	4.00	.....	.....	4.00	.....	.....	.....
Oats, grain.......	1 bu.	.66	.11	.06	.16	.04	.02	.01
Oat straw........	1 ton	12.40	2.00	4.14	20.80	2.80	6.00	1.12
Clover seed.......	1 bu.	1.75	.50	.....	.75	.25	.13	.....
Clover hay.......	1 ton	40.00	5.00	3.28	30.00	7.75	29.25	1.00

ton, as the case may be. From these data the amount of any element removed from an acre of land by a crop of a given yield can easily be computed.

It needs no argument to show that the continuous removal of such quantities of plant food without provision for their replacement must result sooner or later in soil depletion.

PLANT-FOOD SUPPLY

Of the ten elements of plant food, three (*carbon, oxygen,* and *hydrogen*) are secured from air and water, and seven from the soil. *Nitrogen,* one of these seven elements obtained from the soil by all plants, may also be secured from the

TABLE B.—PLANT-FOOD ELEMENTS IN MANURE, ROUGH FEEDS, AND FERTILIZERS

Material	Pounds of plant food per ton of material		
	Nitrogen	Phosphorus	Potassium
Fresh farm manure................................	10	2	8
Corn stover................................	16	2	17
Oat straw................................	12	2	21
Wheat straw................................	10	2	19
Clover hay................................	40	5	30
Cowpea hay................................	43	5	33
Alfalfa hay................................	50	4	24
Sweet clover (water-free basis)[1]......................	80	8	28
Dried blood................................	280	...	...
Sodium nitrate................................	310	...	...
Ammonium sulfate................................	400	...	...
Raw bone meal................................	80	180	...
Steamed bone meal................................	20	250	...
Raw rock phosphate................................	...	250	...
Acid phosphate................................	...	125	...
Potassium chlorid................................	...	...	850
Potassium sulfate................................	...	...	850
Kainit................................	...	...	200
Wood ashes[2]................................	...	10	100

[1]Young second year's growth ready to plow under as green manure.
[2]Wood ashes also contain about 1,000 pounds of lime (calcium carbonate) per ton.

air by one class of plants (legumes), in case the amount liberated from the soil is insufficient; but even these plants (which include only the clovers, peas, beans, and vetches among our common agricultural plants) are dependent upon the soil for the other six elements (*phosphorus, potassium, magnesium, calcium, iron,* and *sulfur*), and they also utilize the soil nitrogen so far as it becomes soluble and available during their period of growth.

The vast difference with respect to the supply of these essential plant food elements in different soils is well brought out in the data of the Illinois soil survey. For example, it has been found that the nitrogen in the surface 6⅔ inches, which represents the plowed stratum, varies in amount from 180 pounds per acre to nearly 33,000 pounds. In like manner the phosphorus content varies from about 420 to 4,900 pounds, the potassium ranges from 1,530 to about 58,000 pounds. Similar variations are found in all of the other essential plant food elements of the soil.

With these facts in mind it is easy to understand how a deficiency of one of these elements of plant food may become a limiting factor of crop production. When an element becomes so reduced in quantity as to become a limiting factor of production, then we must look for some outside source of supply. Table B is presented for the purpose of furnishing information regarding the quantity of plant food contained in some of the materials most commonly used as sources of plant-food supply.

LIBERATION OF PLANT FOOD

The chemical analysis of the soil gives the invoice of fertility actually present in the soil strata sampled and analyzed, but the rate of liberation is governed by many factors, some of which may be controlled by the farmer, while others are largely beyond his control. Chief among the important controllable factors which influence the liberation of plant food are the choice of crops to be grown, the use of limestone, and the incorporation of organic matter. Tillage, especially plowing, also has a considerable effect in this connection.

Feeding Power of Plants.—Different species of plants exhibit a very great diversity in their ability to obtain plant food directly from the insoluble minerals of the soil. As a class, the legumes—especially such biennial and perennial legumes as red clover, sweet clover, and alfalfa—are endowed with unusual power to assimilate from mineral sources such plant foods as calcium and phosphorus, converting them into available forms of food for the crops that follow. For this reason it is especially advantageous to employ such legumes in connection with the application of limestone and rock phosphate. Thru their growth and subsequent decay large quantities of the mineral foods are liberated for the benefit of the less independent feeding cereal crops which follow in the rotation. Moreover, as an effect of the deep rooting habit of these legumes, large quantities of mineral plant foods are brought up and rendered available from the vast reservoirs of the lower subsoil.

Effect of Limestone.—Limestone corrects the acidity of the soil and thus encourages the development not only of the nitrogen-gathering bacteria which live in the nodules on the roots of clover, cowpeas, and other legumes, but also the nitrifying bacteria, which have power to transform the insoluble and unavailable organic nitrogen into soluble and available nitrate nitrogen. At the

same time, the products of this decomposition have power to dissolve the minerals contained in the soil, such as potassium and magnesium, and also to dissolve the insoluble phosphate and limestone which may be applied in low-priced forms. Thus, in the conversion of sufficient organic nitrogen into nitrate nitrogen for a 100-bushel crop of corn, the nitrous acid formed is alone sufficient to convert seven times as much insoluble tricalcium phosphate into soluble monocalcium phosphate as would be required to supply the phosphorus for the same crop.

Organic Matter and Biological Action.—Organic matter may be supplied by animal manures, consisting of the excreta of animals and usually accompanied by more or less stable litter; and by plant manures, including green-manure crops and cover crops plowed under, and also crop residues such as stalks, straw, and chaff. The rate of decay of organic matter depends largely upon its age, condition, and origin, and it may be hastened by tillage. The chemical analysis shows correctly the total organic carbon, which constitutes, as a rule, but little more than half the organic matter; so that 20,000 pounds of organic carbon in the plowed soil of an acre corresponds to nearly 20 tons of organic matter. But this organic matter consists largely of the old organic residues that have accumulated during the past centuries because they were resistant to decay, and 2 tons of clover or cowpeas plowed under may have greater power to liberate plant food than the 20 tons of old, inactive organic matter. The history of the individual farm or field must be depended upon for information concerning recent additions of active organic matter, whether in applications of farm manure, in legume crops, or in sods of old pastures.

The condition of the organic matter of the soil is indicated to some extent by the *ratio of carbon to nitrogen.* Fresh organic matter recently incorporated with the soil contains a very much higher proportion of carbon to nitrogen than do the old resistant organic residues of the soil. The proportion of carbon to nitrogen is higher in the surface soil than in the corresponding subsoil, and in general this ratio is wider in highly productive soils well charged with active organic matter than in very old, worn soils badly in need of active organic matter.

The organic matter furnishes food for bacteria, and as it decays certain decomposition products are formed, including much carbonic acid, some nitrous acid, and various organic acids, and these acting upon the soil have the power to dissolve the essential mineral plant foods, thus furnishing soluble phosphates, nitrates, and other salts of potassium, magnesium, calcium, etc., for the use of the growing crop.

Effect of Tillage.—Tillage, or cultivation, also hastens the liberation of plant food by permitting the air to enter the soil. It should be remembered, however, that tillage is wholly destructive, in that it adds nothing whatever to the soil, but always leaves it poorer, so far as plant food is concerned. Tillage should be practiced so far as is necessary to prepare a suitable seed bed for root development and also for the purpose of killing weeds, but more than this is unnecessary and unprofitable; and it is much better actually to enrich the soil by proper applications of limestone, organic matter and other fertilizing materials, and thus promote soil conditions favorable for vigorous plant growth, than to depend upon excessive cultivation to accomplish the same object at the expense of the soil.

PERMANENT SOIL IMPROVEMENT

According to the kind of soil involved, any comprehensive plan contemplating a permanent system of agriculture will need to take into account some of the following considerations.

The Application of Limestone

The Function of Limestone.—In considering the application of limestone to land it should be understood that this material functions in several different ways, and that a beneficial result may therefore be attributable to quite diverse causes. Limestone provides the plant food calcium, of which certain crops are strong feeders. It corrects acidity of the soil, thus making for some crops a much more favorable environment as well as establishing conditions absolutely required for some of the beneficial legume bacteria. It accelerates nitrification and nitrogen fixation. It promotes sanitation of the soil by preventing the growth of certain fungus diseases, such as corn root rot. Experience indicates that it modifies either directly or indirectly the physical structure of fine-textured soils, frequently to their great improvement.

Thus, working in one or more of these different ways, limestone often becomes the key to the improvement of worn lands. Remarkable success has been experienced with limestone used in conjunction with sweet clover in the reclamation of abandoned hill land which had been ruined thru erosion.

Amounts to Apply.—If the soil is acid, usually at least 2 tons per acre of ground limestone should be applied as an initial treatment. Continue to apply limestone from time to time according to the requirement of the soil as indicated by the tests described below, or until the most favorable conditions are established for the growth of legumes, using preferably at times magnesian limestone ($CaCO_3MgCO_3$), which contains both calcium and magnesium and has slightly greater power to correct soil acidity, ton for ton, than the ordinary calcium limestone ($CaCO_3$). On strongly acid soils, or on land being prepared for alfalfa, 4 or 5 tons per acre of ground limestone may well be used for the first application.

How to Ascertain the Need for Limestone.—The need of a soil for limestone may be ascertained by applying one of the following tests for soil acidity. Along with the acidity test, a test for the presence of carbonates should be made. It should be understood that a positive test for carbonates does not guarantee the absence of acid; for it may happen, especially when the soil is near the neutral point, that positive tests for both acidity and carbonates are obtained. This condition is explained by the assumption that solid particles of calcium or magnesium carbonates form centers of alkalinity within a soil that is generally acid. Because of this fact any test made of a given soil ought to be repeated if it is to be thoroly reliable. It is also desirable to test samples from different depths. Following are the directions for making these tests:

The Litmus Paper Test for Acidity. Make a ball of fresh moist soil, break it in two, insert a piece of blue litmus paper, and press the soil firmly together. After a few minutes examine the paper. If it has turned pink or red, soil acidity is indicated. The intensity of the color and the rapidity with which it develops indicates to some extent the amount of acidity. Needless to say the reliability of the test depends upon the quality of litmus paper used.

The Potassium Thiocyanate Test for Acidity. A more recently discovered test for soil acidity which promises to be more satisfactory than the litmus test is made with a 4-percent solution of potassium thiocyanate in alcohol—4 grams of potassium thiocyanate in 100 cubic centimeters of 95-percent alcohol (not denatured). When a small quantity of soil shaken up in a test tube with this solution gives a red color the soil is acid and limestone should be applied. If the solution remains colorless the soil is not acid. The conditions for a prompt reaction require a temperature that is comfortably warm.

The Hydrochloric Acid Test for Carbonates. Make a shallow cup of a ball of soil and pour into it a few drops of concentrated hydrochloric acid. If carbonates are present they are decomposed with the liberation of carbon dioxid, which appears as gas bubbles, producing foaming or effervescence. With much carbonate present the action is lively, but with mere traces of it the bubbles are given off slowly. If no carbonate, or very little, is indicated by the test, then it is advisable to apply limestone.

The Nitrogen Problem

Nitrogen presents the greatest practical soil problem in American agriculture. Four important reasons for this are: its increasing deficiency in most soils; its cost when purchased on the open market; its removal in large amounts by crops; and its loss from soils thru leaching. Nitrogen costs from four to five times as much per pound as phosphorus. A 100-bushel crop of corn requires 150 pounds of nitrogen for its growth, but only 23 pounds of phosphorus. The loss of nitrogen from soils may vary from a few pounds to over one hundred pounds per acre, depending upon the treatment of the soil, the distribution of rainfall, and the protection afforded by growing crops.

An inexhaustible supply of nitrogen is present in the air. Above each acre of the earth's surface there are about sixty-nine million pounds of atmospheric nitrogen. The nitrogen above one square mile weighs twenty million tons, an amount sufficient to supply the entire world for four or five decades. This large supply of nitrogen in the air is the one to which the world must eventually turn.

There are two methods of collecting the inert nitrogen gas of the air and combining it into compounds that will furnish products for agricultural uses. *These are the chemical and the biological fixation of the atmospheric nitrogen.* Farmers have at their command one of these methods. By growing inoculated legumes, nitrogen may be obtained from the air, and by plowing under more than the roots of those legumes, nitrogen may be added to the soil.

Inasmuch as legumes are worth growing for feed and seed as well as for nitrate production, a considerable portion of the nitrogen thus gained may be considered a by-product. Because of that fact, it is questionable whether the chemical fixation of nitrogen, the possibilities of which now represent numerous compounds, will ever be able to replace the simple method of obtaining atmospheric nitrogen by growing inoculated legumes.

For easy figuring it may well be kept in mind that the following amounts of nitrogen are required for the produce named:

1 bushel of oats (grain and straw) requires 1 pound of nitrogen.
1 bushel of corn (grain and stalks) requires 1½ pounds of nitrogen.
1 bushel of wheat (grain and straw) requires 2 pounds of nitrogen.
1 ton of timothy contains 24 pounds of nitrogen.
1 ton of clover contains 40 pounds of nitrogen.
1 ton of cowpeas contains 43 pounds of nitrogen.
1 ton of alfalfa contains 50 pounds of nitrogen.
1 ton of average manure contains 10 pounds of nitrogen.
1 ton of young sweet clover, at about the stage of growth when it is plowed under as green manure, contains, on water-free basis, 80 pounds of nitrogen.

The roots of clover contain about half as much nitrogen as the tops, and the roots of cowpeas contain about one-tenth as much as the tops. Soils of moderate productive power will furnish as much nitrogen to clover (and two or three times as much to cowpeas) as will be left in the roots and stubble. In grain crops, such as wheat, corn, and oats, about two-thirds of the nitrogen is contained in the grain and one-third in the straw or stalks.

The Phosphorus Problem

The element phosphorus is an indispensable constituent of every living cell. It is intimately connected with the life processes of both plants and animals, the nuclear material of the cells being especially rich in this element.

The phosphorus content of a soil varies according to its origin and the kind of farming practiced. Even virgin soils are found that are deficient in phosphorus.

On all lands deficient in phosphorus (except on those susceptible to serious erosion by surface washing or gullying) that element should be applied in considerably larger amounts than are required to meet the actual needs of the crops desired to be produced. The abundant information thus far secured shows positively that finely ground natural rock phosphate can be used successfully and very profitably, and clearly indicates that this material will be the most economical form of phosphorus to use in all ordinary systems of permanent, profitable soil improvement. The first application may well be one ton per acre, and subsequently about one-half ton per acre every four or five years should be applied, at least until the phosphorus content of the plowed soil reaches 2,000 pounds per acre, which may require a total application of from 3 to 5 or 6 tons per acre of raw phosphate containing 12½ percent of the element phosphorus.

Steamed bone meal and even acid phosphate may be used in emergencies, but it should always be kept in mind that a pound of phosphorus delivered in Illinois in the form of raw phosphate (direct from the mine in carload lots), is much cheaper than the same amount in steamed bone meal or in acid phosphate, both of which cost too much per ton to permit their common purchase by farmers in carload lots, which is not the case with raw phosphate. Landowners should bear in mind the fact that phosphorus additions to the soil in amounts above the immediate crop requirements represent a permanent investment, since this element is not readily lost in the drainage water as in the case of nitrogen. It is removed from the farm thru the sale of crops, milk, and animals.

Phosphate may be applied at any time during a rotation, but it is applied to the best advantage either preceding a crop of clover, which plant seems to possess an unusual power for assimilating raw phosphate, or else at a time when it can be plowed under with some form of organic matter such as animal manure or green manure, the decay of which serves to liberate the phosphorus from its insoluble condition in the rock. It is important that the finely ground rock phosphate be intimately mixed with the organic material as it is plowed under.

The Potassium Problem

Normal soils, in which clay and silt form a considerable part of the constituency, are well stocked with potassium, altho it exists largely in insoluble

form. Such soils as sands and peats, however, are likely to be low in this element. On such soils this deficiency may be supplied by the application of some potassium salt, such as potassium sulfate, potassium chlorid, kainit, or other potassium compound, and in many instances this is done at great profit.

From all the facts at hand it seems, so far as our great areas of normal soils are concerned, that the potassium problem is not one of addition but of liberation. The Rothamsted records, which represent the oldest soil experiment fields in the world, show that for many years other soluble salts have had practically the same power as potassium to increase crop yields in the absence of sufficient decaying organic matter. Whether this action relates to supplying or liberating potassium for its own sake, or to the power of the soluble salt to increase the availability of phosphorus or other elements, is not known, but where much potassium is removed, as in the entire crops at Rothamsted, with no return of organic residues, probably the soluble salt functions in both ways.

Further evidence on this matter is furnished by the Illinois experiment field at Fairfield, where potassium sulfate has been compared with kainit both with and without the addition of organic matter in the form of stable manure. Both sulfate and kainit produced a substantial increase in the yield of corn, but the cheaper salt—kainit—was just as effective as the potassium sulfate, and returned some financial profit. Manure alone gave an increase similar to that produced by the potassium salts, but the salts added to the manure gave very little increase over that produced by the manure alone. This is explained in part perhaps because the potassium removed in the crops is mostly returned in the manure if properly cared for, and perhaps in larger part because the decaying organic matter helps to liberate and hold in solution other plant-food elements, especially phosphorus.

In laboratory experiments at the Illinois Experiment Station, it has been shown that potassium salts and most other soluble salts increase the solubility of the phosphorus in soil and in rock phosphate; also that the addition of glucose with rock phosphate in pot-culture experiments increases the availability of the phosphorus, as measured by plant growth, altho the glucose consists only of carbon, hydrogen, and oxygen, and thus contains no plant food of value.

In considering the conservation of potassium on the farm it should be remembered that in average live-stock farming the animals destroy two-thirds of the organic matter and retain one-fourth of the nitrogen and phosphorus from the food they consume, but that they retain less than one-tenth of the potassium; so that the actual loss of potassium in the products sold from the farm, either in grain farming or in live-stock farming, is negligible on land containing 25,000 pounds or more of potassium in the surface 6⅔ inches.

The Calcium and Magnesium Problem

When measured by the actual crop requirements for plant food, magnesium and calcium are more limited in some Illinois soils than potassium. But with these elements we must also consider the loss by leaching.

Doctor Edward Bartow and associates, of the Illinois State Water Survey, have shown that as an average of 90 analyses of Illinois well-waters drawn chiefly from glacial sands, gravels, or till, 3 million pounds of water (about the average

annual drainage per acre for Illinois) contained 11 pounds of potassium, 130 of magnesium, and 330 of calcium. These figures are very significant, and it may be stated that if the plowed soil is well supplied with the carbonates of magnesium and calcium, then a very considerable proportion of these amounts will be leached from that stratum. Thus the loss of calcium from the plowed soil of an acre at Rothamsted, England, where the soil contains plenty of limestone, has averaged more than 300 pounds a year as determined by analyzing the soil in 1865 and again in 1905. And practically the same amount of calcium was found by analyzing the Rothamsted drainage waters.

Common limestone, which is calcium carbonate ($CaCO_3$), contains, when pure, 40 percent of calcium, so that 800 pounds of limestone is equivalent to 320 pounds of calcium. Where 10 tons per acre of ground limestone was applied at Edgewood, Illinois, the average annual loss during the next ten years amounted to 790 pounds per acre. The definite data from careful investigations thus seem to indicate that where limestone is needed at least 2 tons per acre should be applied every four or five years.

It is of interest to note that thirty crops of clover of 4 tons each would require 3,510 pounds of calcium, while the most common prairie land of southern Illinois contains only 3,420 pounds of total calcium in the plowed soil of an acre. Thus limestone has a positive value on some soils for the plant food which it supplies, in addition to its value in correcting soil acidity and in improving the physical condition of the soil. Ordinary limestone (abundant in the southern and western parts of the state) contains nearly 800 pounds of calcium per ton; while a good grade of dolomitic limestone (the more common limestone of northern Illinois) contains about 400 pounds of calcium and 300 pounds of magnesium per ton. Both of these elements are furnished in readily available form in ground dolomitic limestone.

The Sulfur Question

In considering the relation of sulfur in a permanent system of soil fertility it is important to understand something of the cycle of transformations that this element undergoes in nature. Briefly stated this is as follows:

Sulfur exists in the soil in both organic and inorganic forms, the former being gradually converted to the latter form thru bacterial action. In this inorganic form sulfur is taken up by plants which in their physiological processes change it once more into an organic form as a constituent of protein. When these plant proteins are consumed by animals, the sulfur becomes a part of the animal protein. When these plant and animal proteins are decomposed, either thru bacterial action, or thru combustion, the sulfur passes into the atmosphere or into the soil solution in the form of sulfur dioxid gas. This gas unites with oxygen and water to form sulfuric acid, which is readily washed back into the soil by the rain, thus completing the cycle, from soil—to plants and animals —to air—to soil.

In this way sulfur becomes largely a self-renewing element of the soil, altho there is a considerable loss from the soil by leaching. Observations taken at the Illinois Agricultural Experiment Station show that 40 pounds of sulfur per acre are brought into the soil thru the annual rainfall. With a fair stock of

sulfur, such as exists in our common types of soil, and an annual return, which of itself would more than suffice for the needs of maximum crops, the maintenance of an adequate sulfur supply presents little reason at present for serious concern. There are regions, however, where the natural stock of sulfur in the soil is not nearly so high and where the amount returned thru rainfall is small. Under such circumstances sulfur soon becomes a limiting element of crop production, and it will be necessary sooner or later to introduce this substance from some outside source. Investigation is now under way to determine to what extent this situation may apply to conditions in Illinois.

Physical Improvement of Soils

In the management of most soil types, one very important thing, aside from proper fertilization, tillage, and drainage, is to keep the soil in good physical condition, or good tilth. The constituent most important for this purpose is organic matter. Organic matter in producing good tilth helps to control washing of soil on rolling land, raises the temperature of drained soil, increases the moisture-holding capacity of the soil, retards capillary rise and consequently loss of moisture by surface evaporation, and helps to overcome the tendency of some soils to run together badly.

The physical effect of organic matter is to produce a granulation or mellowness, by cementing the fine soil particles into crumbs or grains about as large as grains of sand, which produces a condition very favorable for tillage, percolation of rainfall, and the development of plant roots.

Organic matter is being destroyed during a large part of the year and the nitrates produced in its decomposition are used for plant growth. Altho this decomposition is necessary, it nevertheless reduces the amount of organic matter, and provision must therefore be made for maintaining the supply. The practical way to do this is to turn under the farm manure, straw, corn stalks, weeds, and all or part of the legumes produced on the farm. The amount of legumes needed depends upon the character of the soil. There are farms, especially grain farms, in nearly every community where all legumes could be turned under for several years to good advantage.

Manure should be spread upon the land as soon as possible after it is produced, for if it is allowed to lie in the barnyard several months as is so often the case, from one-third to two-thirds of the organic matter will be lost.

Straw and corn stalks should be turned under, and not burned. Probably no form of organic matter acts more beneficially in producing good tilth than corn stalks. It is true, they decay rather slowly, but it is also true that their durability in the soil is exactly what is needed in the production of good tilth. Furthermore, the nitrogen in a ton of corn stalks is one and one-half times that of a ton of manure, and a ton of dry corn stalks incorporated in the soil will ultimately furnish as much humus as four tons of average farm manure. When burned, however, both the humus-making material and the nitrogen are lost to the soil.

It is a common practice in the corn belt to pasture the corn stalks during the winter and often rather late in the spring after the frost is out of the ground. This tramping by stock sometimes puts the soil in bad condition for

working. It becomes partially puddled and will be cloddy as a result. If tramped too late in the spring, the natural agencies of freezing and thawing and wetting and drying, with the aid of ordinary tillage, fail to produce good tilth before the crop is planted. Whether the crop is corn or oats, it necessarily suffers, and if the season is dry, much damage may be done. If the field is put in corn, a poor stand is likely to result, and if put in oats, the soil is so compact as to be unfavorable for their growth. Sometimes the soil is worked when too wet. This also produces a partial puddling which is unfavorable to physical, chemical, and biological processes. The bad effect will be greater if cropping has reduced the organic matter below the amount necessary to maintain good tilth.

Systems of Crop Rotations

In a program of permanent soil improvement one should adopt at the outset a good rotation of crops, including a liberal use of legumes, in order to increase the organic matter of the soil either by plowing under the legume crops and other crop residues (straw and corn stalks), or by using for feed and bedding practically all the crops raised and returning the manure to the land with the least possible loss. No one can say in advance for every particular case what will prove to be the best rotation of crops, because of variation in farms and farmers and in prices for produce.

Following are a few suggested rotations, applicable to the corn belt, which may serve as models or outlines to be modified according to special circumstances.

Six-Year Rotations

First year —Corn
Second year —Corn
Third year —Wheat or oats (with clover, or clover and grass)
Fourth year —Clover, or clover and grass
Fifth year —Wheat (with clover), or grass and clover
Sixth year —Clover, or clover and grass

Of course there should be as many fields as there are years in the rotation. In grain farming, with small grain grown the third and fifth years, most of the unsalable products should be returned to the soil, and the clover may be clipped and left on the land or returned after threshing out the seed (only the clover seed being sold the fourth and sixth years); or, in live-stock farming, the field may be used three years for timothy and clover pasture and meadow if desired. The system may be reduced to a five-year rotation by cutting out either the second or the sixth year, and to a four-year system by omitting the fifth and sixth years, as indicated below.

Five-Year Rotations

First year —Corn
Second year —Wheat or oats (with clover, or clover and grass)
Third year —Clover, or clover and grass
Fourth year —Wheat (with clover), or clover and grass
Fifth year —Clover, or clover and grass

First year —Corn
Second year —Corn
Third year —Wheat or oats (with clover, or clover and grass)
Fourth year —Clover, or clover and grass
Fifth year —Wheat (with clover)

First year —Corn
Second year —Cowpeas or soybeans
Third year —Wheat (with clover)
Fourth year —Clover
Fifth year —Wheat (with clover)

The last rotation mentioned above allows legumes to be seeded four times. Alfalfa may be grown on a sixth field for five or six years in the combination rotation, alternating between two fields every five years, or rotating over all the fields if moved every six years.

Four-Year Rotations

First year —Wheat (with clover)
Second year —Corn
Third year —Oats (with clover)
Fourth year —Clover

First year —Corn
Second year —Corn
Third year —Wheat or oats (with clover)
Fourth year —Clover

First year —Corn
Second year —Wheat or oats (with clover)
Third year —Clover
Fourth year —Wheat (with clover)

First year —Wheat (with clover)
Second year —Clover
Third year —Corn
Fourth year —Oats (with clover)

First year —Corn
Second year —Cowpeas or soybeans
Third year —Wheat (with clover)
Fourth year —Clover

Alfalfa may be grown on a fifth field for four or eight years, which is to be alternated with one of the four; or the alfalfa may be moved every five years, and thus rotated over all five fields every twenty-five years.

Three-Year Rotations

First year —Corn
Second year —Oats or wheat (with clover)
Third year —Clover

First year —Wheat (with clover)
Second year —Corn
Third year —Cowpeas or soybeans

By allowing the clover, in the last rotation mentioned, to grow in the spring before preparing the land for corn, we have provided a system in which legumes grow on every acre every year. This is likewise true of the following suggested two-year system:

Two-Year Rotations

First year —Oats or wheat (with sweet clover)
Second year —Corn

Altho in this two-year rotation either oats or wheat is suggested, as a matter of fact, by dividing the land devoted to small grain, both of these crops can be grown simultaneously, thus providing a three-crop system in a two-year cycle.

It should be understood that in all of the above suggested cropping systems it may be desirable in some cases to substitute rye for the wheat or oats. In all of these proposed rotations the word *clover* is used in a general sense to designate either red clover, alsike clover, or sweet clover. The value of sweet clover especially as a green manure for building up depleted soils, as well as a pasture and hay-crop, is becoming thoroly established, and its importance in a crop-rotation program may well be emphasized.

SUPPLEMENT: EXPERIMENT FIELD DATA

(Results from Experiment Fields Representing the More Important Types of Soil Occurring in DeKalb County)

In the earlier reports of this series it was the practice to incorporate in the body of the report the results of certain experiment fields, for the purpose of illustrating the possibilities of improving the soil of various types. The information carried by such data must, naturally, be considered more or less tentative. As the fields grow older new facts develop, which in some instances may call for the modification of former recommendations. It has therefore seemed desirable to separate this experiment field data from the more permanent information of the soil survey, and embody the same in the form of a supplement to the soil report proper, thus providing a convenient arrangement for possible future revisions as additional data accumulate.

The University of Illinois has conducted altogether about fifty soil experiment fields in different sections of the state and on various types of soil. Altho some of these fields have been discontinued, the large majority are still in operation. It is the present purpose to report the summarized results from certain of these fields which are representative of the types of soil described in the accompanying soil report.

A few general explanations at this point, which apply to all the fields, will relieve the necessity of numerous repetitions in the following pages.

Size and Arrangement

These fields vary in size from less than two acres up to 40 acres or more. They are laid off into series of plots, the plots commonly being either one-fifth or one-tenth acre in area. Each series is occupied by one kind of crop. Usually there are several series so that a crop rotation can be carried on with every crop represented every year.

Farming Systems

On many of the fields the treatment provides for two distinct systems of farming, live-stock farming and grain farming.

In the live-stock system, stable manure is used to furnish organic matter and nitrogen. The amount applied to a plot is based upon the amount that can be produced from crops raised on that plot.

In the grain system no animal manure is used. The organic matter and nitrogen are applied in form of plant manures, including all the plant residues produced, such as corn stalks, straw from wheat, oats, clover, etc., along with leguminous catch crops plowed under. It is the plan in this latter system to remove from the land, in the main, only the grain and seed produced, except in the case of alfalfa, that crop being harvested for hay the same as in the live-stock system.

Crop Rotations

Crops which are of interest in the respective localities are grown in definite rotations, and on most of the fields provision is made so that every crop in the rotation is represented every year. The most common rotation used is wheat,

corn, oats, and clover; and often these crops are accompanied by alfalfa growing on a fifth series. In the grain system a legume catch crop, usually sweet clover, is included, which is seeded on the young wheat in the spring and plowed under in the fall or in the following spring in preparation for corn. In the event of clover failure, soybeans are substituted.

Soil Treatment

The treatment applied to the plots has, in large part, been standardized according to a rather definite system, altho many deviations from this system occur.

Following is a brief explanation of this standard system of treatment.

Animal Manures.—Animal manures, consisting of excreta from animals, with stable litter, are spread upon the respective plots in amounts proportionate to previous crop yields, the applications being made in the preparation for corn.

Plant Manures.—All crop residues produced on the land, such as stalks, straw, and chaff, are returned to the soil, and in addition a green-manure crop of sweet clover is seeded in small grains to be plowed under in preparation for corn. (On plots where limestone is lacking the sweet clover seldom survives.) This practice is designated as the *residues system.*

Mineral Manures.—The usual yearly acre-rates of application have been: for limestone, 1,000 pounds; for raw rock phosphate, 500 pounds; and for potassium, the equivalent of 200 pounds of kainit. The initial application of limestone has usually been 4 tons per acre.

Explanation of Symbols Used

0 = Untreated land or check plots
M = Manure (animal)
R = Residues (from crops, and includes legumes used as green manure)
L = Limestone
P = Phosphorus
K = Potassium (usually in the form of kainit)
N = Nitrogen (usually in the form contained in dried blood)
( ) = Parentheses enclosing figures signify tons of hay, as distinguished from bushels of seed

In discussions of this sort of data, financial profits or losses based upon assigned market values are frequently considered. However, in view of the erratic fluctuations in market values—especially in the past few years—it seems futile to attempt to set any prices for this purpose that are at all satisfactory. The yields are therefore presented with the thought that with these figures at hand the financial returns from a given practice can readily be computed upon the basis of any set of market values that the reader may choose to apply.

BROWN SILT LOAM

Several experiment fields have been conducted on brown silt loam soil at various locations in Illinois. Those located at the University have been in operation the longest and they serve well to illustrate the principles involved in the maintenance and improvement of this type of soil.

The Morrow Plots

It happens that the oldest soil experiment field in the United States is located on typical brown silt loam of the early Wisconsin glaciation, on the campus of the University of Illinois. This field was started in 1879 by George E. Morrow, who for many years was Professor of Agriculture, and these plots are known as the Morrow plots.

The Morrow series now consists of three plots divided into halves and the halves are subdivided into quarters. On one plot corn is grown continuously; on the second, corn and oats are grown in rotation; and on the third, corn, oats, and clover are rotated. The north half of each plot has had no fertilizing material applied from the beginning of the experiments, while the south half has been treated since 1904, receiving standard applications of farm manure with cover crops grown in the one-crop and two-crop systems. Phosphorus has been applied in two different forms: rock phosphate to the southwest quarter at the rate of 600 pounds, and steamed bone meal to the southeast quarter at the rate of 200 pounds per acre per year up to 1919, when the rock phosphate was increased sufficiently to bring up the total amount applied to four times the quantity of bone meal applied. At the same time the rate of subsequent application of both forms of phosphorus was reduced to one-fourth the quantity, or to 200 pounds of rock phosphate and 50 pounds of bone meal per acre per year. In 1904 ground limestone was applied at the rate of 1,700 pounds per acre to the south half of each plot, and in 1918 a further application was made at the rate of 5 tons per acre with the intention of standardizing the application to the rate of 1,000 pounds of limestone per acre per year.

Table 1 gives the yearly record of the crop yields, and Table 2 presents the same in summarized form.

Fig. 1.—Corn on the Morrow Plots in 1910

TABLE 1.—URBANA FIELD, MORROW PLOTS: BROWN SILT LOAM; PRAIRIE; EARLY WISCONSIN GLACIATION

Crop Yields in Soil Experiments—Bushels or (tons) per acre

Years	Soil treatment applied	Corn every year	Two-year rotation		Three-year rotation		
		Corn	Corn	Oats	Corn	Oats	Clover
1879–87	None........	....	....	....	....	....	....
1888	None........	54.3	49.5	....	....	48.6	....
1889	None........	43.2	....	37.4	....	....	(4.04)
1890	None........	48.7	54.3	....	....	....	(1.51)
1891	None........	28.6	33.2	....	....	....	(1.46)
1892	None........	33.1	....	37.2	70.2	....	....
1893	None........	21.7	29.6	....	34.1	....	....
1894	None........	34.8	....	57.2	....	65.1	....
1895	None........	42.2	41.6	....	....	22.2	....
1896	None........	62.3	....	34.5	....	....	....
1897	None........	40.1	47.0	....	....	....	....
1898	None........	18.1	....	....	....	....	....
1899	None........	50.1	44.4	....	53.5	....	....
1900	None........	48.0	....	41.5	....	....	....
1901	None........	23.7	33.7	....	34.3	....	....
1902	None........	60.2	....	56.3	....	54.6	....
1903	None........	26.0	35.9	....	....	....	(1.11)
1904	None........	21.5	....	17.5	55.3	....	....
1904	MLP........	17.1	....	25.3	72.7	....	....
1905	None........	24.8	50.0	....	....	42.3	....
1905	MLP........	31.4	44.9	....	....	50.6	....
1906	None........	27.1	....	34.7	....	....	(1.42)[1]
1906	MLP........	35.8	....	52.4	....	....	(1.74)[1]
1907	None........	29.0	47.8	....	80.5	....	....
1907	MLP........	48.7	87.6	....	93.6	....	....
1908	None........	13.4	....	32.9	....	40.0	....
1908	MLP........	28.0	....	45.0	....	44.4	....
1909	None........	26.6	33.0	....	....	....	(.65)[2]
1909	MLP........	31.6	64.8	....	....	....	(1.73)[3]
1910	None........	35.9	....	33.8	58.6	....	....
1910	MLP........	54.6	....	59.4	83.3	....	....
1911	None........	21.9	28.6	....	....	20.6	....
1911	MLP........	31.5	46.3	....	....	38.0	....
1912	None........	43.2	....	55.0	....	....	16.3[1]
1912	MLP........	64.2	....	81.0	....	....	20.0[1]
1913	None........	19.4	29.2	....	33.8	....	....
1913	MLP........	32.0	25.0	....	47.8	....	....
1914	None........	31.6	....	33.6	....	39.6	....
1914	MLP........	39.4	....	58.2	....	60.4	....
1915	None........	40.0	49.0	....	....	....	24.2[1]
1915	MLP........	66.0	81.2	....	....	....	27.1[1]
1916	None........	11.2	....	37.5	27.8	....	....
1916	MLP........	10.8	....	64.7	40.6	....	....
1917	None........	40.0	48.4	....	....	68.4	....
1917	MLP........	78.0	81.4	....	....	86.9	....
1918	None........	13.6	....	27.2	....	....	(2.58)
1918	MLP........	32.6	....	59.3	....	....	(4.04)
1919	None........	24.0	30.8	....	52.2	....	....
1919	MLP........	43.4	66.2	....	70.8	....	....
1920	None........	28.2	....	37.2	....	52.2	....
1920	MLP........	54.4	....	51.6	....	69.7	....
1921	None........	19.8	30.6	....	....	....	(.26)[4]
1921	MLP........	42.2	68.4	...	....	....	(1.33)[5]

[1]Soybeans.
[2]In addition to the hay, .64 bushel of seed was harvested.
[3]In addition to the hay, 1.17 bushels of seed were harvested.
[4]In addition to the hay, .53 bushel of seed was harvested.
[5]In addition to the hay, .85 bushel of seed was harvested.

TABLE 2.—URBANA FIELD, MORROW PLOTS: GENERAL SUMMARY
Average Annual Yields—Bushels or (tons) per acre

Years	Soil treatment applied	Corn every year	Two-year rotation		Three-year rotation		
			Corn	Oats	Corn	Oats	Clover
		16 crops	*9 crops*	*6 crops*	*4 crops*	*4 crops*	*4 crops*
1888 to 1903	None........	39.7	41.0	44.0	48.0	47.6	(2.03)
		18 crops	*9 crops*	*9 crops*	*6 crops*	*6 crops*	*4 crops*
1904	None........	26.2	38.6	34.4	51.4	43.9	(1.23)[1]
to 1921	MLP........	41.2	62.9	55.2	68.1	58.3	(2.21)[1]

[1]One crop of soybean hay.

Summarizing the data from these Morrow plots into two periods with the second period beginning in 1904 when the treatment began on the half-plots, some interesting comparisons may be made. In the first place we find in the continuous corn plot a marked decrease in the second period in the average yield of corn, amounting to one-third of the crop. In the two-year rotation there is a decrease in both corn and oats production, while the averages for the three-year system show an increase in corn yield and decreases in oats and clover. Unfortunately the numbers of crops included in these last averages are too small to warrant positive conclusions.

The increase brought about by soil treatment stands out in all cases, showing the possibility not only of restoring but also of greatly improving the productive power of this land that has been so abused by continuous cropping without fertilization.

The Davenport Plots

Another set of plots on the University campus at Urbana, forming a more extensive series than the Morrow plots, but of more recent origin, are the Davenport plots. Here each crop in the rotation is represented every year. These plots were laid out in 1895, but special soil treatment was not begun until 1901. They now comprize five series of ten plots each, and each series constitutes a "field" in a crop rotation system.

From 1901 to 1911 three of the series were in a three-year rotation system of corn, oats, and clover, while the remaining two series rotated in corn and oats. In 1911 these two systems were combined into a five-series field, with a crop rotation of wheat, corn, oats, and clover, with alfalfa on a fifth field. The alfalfa occupies one series during a rotation of the other four crops, shifting to another series in the fifth year, thus completing the cycle of all series in twenty-five years.

The soil treatment applied to these plots has been as follows:

Legume cover crops were seeded in the corn at the last cultivation on Plots 2, 4, 6, and 8, from 1902 to 1907, but the growth was small and the effect, if any, was to decrease the returns from the regular crops. Crop residues (**R**) have been returned to these same plots since 1907. These consist of stalks and straw, and all legumes except alfalfa hay and the seed of clover and soybeans. Beginning in 1918 a modification of the practice was made in that one cutting of the red clover crop is harvested as hay. In conjunction with these residues a catch crop of sweet clover grown with the wheat is plowed under.

Manure (**M**) was applied preceding corn, at the rate of 2 tons per acre per year in 1905, 1906, and 1907; subsequently as many tons have been applied as there have been tons of air-dry produce harvested from the respective plots.

Lime (**L**) was applied on Plots 4 to 10 at the rate per acre of 250 pounds of air-slaked lime in 1902, and 600 pounds of limestone in 1903. No further application was made until 1911, when the system of cropping was changed. Since that time applications of limestone have been made at the rate of one-half ton per acre per year.

Phosphorus (**P**) was applied on Plots 6 to 9 at the rate of 25 pounds per acre per annum in 200 pounds of steamed bone meal; but beginning with 1908 rock phosphate at the rate of 600 pounds per acre per annum was substituted for the bone meal on one-half of each of these plots. These applications continued until 1918 when adjustments were begun, first to make the rate of application of rock phosphate four times that of the bone meal, and finally to reduce the amounts of these materials to 200 pounds of rock phosphate and 50 pounds of bone meal per acre per annum. The usual practice has been to apply and plow under at one time all phosphorus and potassium required for the rotation.

Potassium (**K** = kalium) has been applied on Plots 8 and 9, in connection with the organic manures and phosphorus, at the yearly rate of 42 pounds per acre, and mainly as potassium sulfate.

On Plot 10 about five times as much manure and phosphorus are applied as on the other plots, but this "extra heavy" treatment was not begun until 1906, only the usual amounts of lime, phosphorus, and potassium having been applied in previous years. The purpose in making these heavy applications is to try to determine the climatic possibilities in crop yields by removing the limitations of inadequate fertility.

It will be observed that the applications described above provide for the two rather distinct systems of farming already described. *The grain system,* in which animal manure is not produced and where the organic matter is provided by the direct return to the soil of all crop residues along with legumes, is exemplified in Plots 2, 4, 6, and 8; and the *live-stock system,* in which farm manure is utilized for soil enrichment, is represented in Plots 3, 5, 7, and 9.

Table 3 shows a summary of the results obtained on the Davenport plots beginning with the year 1911, when the present cropping system was introduced.

When used in conjunction with phosphorus the crop residues and the manure appear about equally effective; but where phosphorus is not applied, the manure has been decidedly more effective, under the conditions of the experiment. It should be observed, however, in this connection, that the plowing under of clover is a very essential feature of the residues system, and that, as a matter of fact, there were five clover failures, when soybeans were substituted, during the ten years. Perhaps with a more reliable biennial legume than red clover, the results would have been more favorable for this system.

By comparing Plots 2 and 3 with Plots 4 and 5, it is found that limestone has had a beneficial effect on all crops. What the financial profit amounts to depends obviously upon the market value of the crops and the cost of the limestone.

TABLE 3.—URBANA FIELD, DAVENPORT PLOTS: BROWN SILT LOAM, PRAIRIE; EARLY WISCONSIN GLACIATION

Average Annual Yields—Bushels or (tons) per acre
1911–1920

Serial plot No.	Soil treatment applied	Corn	Oats	Wheat	Clover 5 crops	Soybeans 5 crops	Alfalfa
1	0	55.6	50 5	26.0	(2 42)	(1.47)	(2 43)
2	R	57.1	52.3	28.7	1 47[1]	19 8	(2 46)
3	M	66 3	61.9	28.2	(2.56)	(1.62)	(2 52)
4	RL	64 8	55.6	31.4	1.61[1]	20.3	(2.72)
5	ML	69.6	64 1	32 8	(2 90)	(1 67)	(3 03)
6	RLP	71.5	69 8	43 0	2 29[1]	23 5	(3 69)
7	MLP	73.0	68.6	40 0	(3.52)	(1.97)	(3.76)
8	RLPK	70 9	72.5	40.7	1.79[1]	25 5	(3.77)
9	MLPK	70.2	72 0	39.2	(3.40)	(2.20)	(3.73)
10	Mx5LPx5	65 9	71.4	40 6	(3.31)	(2.22)	(3.77)

[1]In addition to the clover seed, a crop of hay was harvested one year on Plots 2, 4, 6, and 8, yielding 2.38, 2.20, 2.54, and 2.39 tons respectively.

Comparing Plots 4 and 5 with Plots 6 and 7, respectively, there is found in all cases an increase in crop yield as a result of adding phosphorus. The effect on wheat is especially pronounced. Where limestone and phosphorus are applied in addition to the crop residues, an increase of 17 bushels of wheat, over the yield of the untreated land, has been obtained as a ten-year average.

Manure
Yield: 1.43 tons per acre

Manure, limestone, phosphorus
Yield: 2.90 tons per acre

FIG. 2.—CLOVER ON THE DAVENPORT PLOTS IN 1913

The effect of adding potassium to the treatment is of much interest. Plots 8 and 9 are the same as Plots 6 and 7, respectively, except that potassium has been applied to the former. On the whole, no significant benefit is shown from the addition of potassium.

No benefit appears as the result of the extra-heavy applications of manure and phosphorus on Plot 10. In fact the corn yields are noticeably less here than on the plots receiving the normal applications of these materials.

The University South Farm

On the University South Farm, at Urbana, several series of plots devoted primarily to variety testing and other crop-production experiments are so laid out as to show the effects of certain soil treatments that have been applied. Several different systems of crop rotation are employed and the crops are so handled as to exemplify the two general systems of farming, grain and live-stock.

The summarized results presented in Table 4 represent three different systems of cropping. The first, designated as the Southwest rotation, is to be regarded as a good rotation for general practice, on this type of soil, under Illinois conditions. This is a four-field rotation of wheat, corn, oats, and clover.

TABLE 4.—URBANA FIELD, SOUTH FARM: BROWN SILT LOAM, PRAIRIE; EARLY WISCONSIN GLACIATION

Average Annual Yields—Bushels or (tons) per acre
1908-1919

Southwest Rotation: Series 100, 200, 400[1]: Wheat, Corn, Oats, Clover[2]

Soil treatment applied[6]	Corn 9 crops	Oats[3] 9 crops	Wheat[3] 8 crops	Clover[4] 3 crops	Soybeans 7 crops
RP	62.3	51.9	41.0	1.05	17.3[5]
R	51.9	46.5	26.9	1.38	16.2[5]
M	59.7	50.2	29.1	(2.28)	(1.25)
MP	64.3	55.4	43.1	(2.86)	(1.51)
RLP	60.5	57.2	41.8	.64	16.4[5]
R	49.7	49.6	25.8	.83	14.7[5]
M	55.5	54.1	27.8	(1.71)	(1.28)
MLP	64.1	59.6	43.9	(1.77)	(1.58)

North-Central Rotation: Series 500, 600, 700[1]: Corn, Corn, Oats, Clover[2]

Soil treatment applied[6]	Corn 1st year 9 crops	Corn 2d year 9 crops	Oats 9 crops	Clover 5 crops	Soybeans 4 crops
RP	56.7	51.1	56.1	.54	16.9
R	51.7	45.2	52.0	.50	16.0
M	54.9	46.7	52.1	(2.29)	(1.60)
MP	56.5	53.4	56.9	(2.73)	(1.74)

South-Central Rotation: Series 500, 600, 700[1]: Corn Corn, Corn, Soybeans

Soil treatment applied[6]	Corn 1st year 9 crops	Corn 2d year 9 crops	Corn 3d year 9 crops		Soybeans 9 crops
RP	51.9	44.0	41.3		20.0
R	45.5	39.9	35.2		19.2
M	50.1	42.1	33.5		(1.59)
MP	54.5	46.7	42.0		(1.66)

[1]Results from Series 300 and 800 are omitted on account of variation in soil type.
[2]Soybeans when clover fails.
[3]Only seven crops with limestone.
[4]Only one crop with limestone.
[5]Average of five crops.
[6]All phosphorus plots received ½ ton per acre of limestone in 1903.

TABLE 5.—COMPARING PRODUCTION OF CORN IN THREE DIFFERENT ROTATION SYSTEMS
YIELDS FROM PLOTS ON THE UNIVERSITY SOUTH FARM

Twelve-Year Average (1908–1919)—Bushels per acre

Rotation	Wheat-corn-oats-legume[1]	Corn-corn-oats-legume[2]		Corn-corn-corn-legume[3]		
Treatment	Corn	1st Corn	2d Corn	1st Corn	2d Corn	3d Corn
Organic manures........	55.8	53.3	46.0	47.8	41 0	34.3
Organic manures, phosphorus...	63.2	56.6	52 3	53 2	45.3	41.6

[1]Clover 3 crops and soybeans 7 crops.
[2]Clover 5 crops, and soybeans 5 crops.
[3]Soybeans 9 crops.

The second, or North-Central rotation, consisting of corn, corn, oats, and clover, represents a system very commonly practiced; and the third or South-Central rotation, consisting of corn, corn, corn, and soybeans, must be considered as a poor rotation from the standpoint of maintaining the productiveness of the land.

On the whole, the "residues" have not returned yields quite so high as those produced by the manure treatment; but, as remarked above in the discussion of the Davenport plots, the residues system has probably been at a disadvantage thru frequent clover failures. On the North-Central rotation, where conditions seem to have been more favorable for clover, there is very little difference between the effect of manure and of residues.

Residues plowed under
Yield: 35.2 bushels per acre

Residues and rock phosphate
Yield: 50.1 bushels per acre

FIG. 3.—WHEAT ON THE UNIVERSITY SOUTH FARM IN 1911

In the rotation system in which limestone is being applied, no benefit of consequence to any of the crops except oats appears from the use of this material. The test, however, has hardly been of sufficient duration to warrant final conclusions; and furthermore, the comparison may be somewhat impaired by a possible residual effect of the small application of limestone made in 1903 to all the phosphorus plots.

The results obtained from the use of phosphorus are important because this element has been applied to these plots solely in the form of raw rock phosphate. The figures in almost every case show an increase in yield where the phosphorus has been applied, and in most cases this increase is very pronounced. The wheat is especially responsive to phosphorus.

The records furnish some interesting comparisons of corn yields produced under different systems of cropping. Table 5 gives a general summary of the corn yields only, in which the results from the residues and manure treatments are averaged together as "organic manures." The highest annual acre-yields are found where corn occurs but once in a rotation. Where corn is grown twice in succession, the annual acre-yields are less; and where corn occurs three times, there is a further reduction. Also, the first crop of corn within a rotation produces more than the second, and the second crop yields more than the third. These are useful facts for consideration in connection with problems of general farm management.

The DeKalb Field

An experiment field located in DeKalb county on the brown silt loam type of soil, just south of the city of DeKalb, has been in operation since 1906. This field was established primarily as a crops experiment field where the investigations relate to such matters as methods of seeding, cultivation, care, handling, and tests of varieties of our common field crops. Incidentally, however, the effects of certain soil treatments on these plots are compared. It is the present purpose to consider only those results that have to do directly with these soil treatments. The results of the strictly crops experiments are presented from time to time in other appropriate bulletins.

The diagram presented as Fig. 4 shows the arrangement of the plots, the system of numbering, the plan of soil treatment, and the cropping systems employed.

Arrangement of Plots.—The plots lie in four series, which number in hundreds from north to south. Each series has two divisions, an east and a west. Each division consists of 18 plots. These plots number from west to east according to the system indicated in the diagram on the 100 series. The plots of the 100 series are one-tenth acre in size, while those on the other series are one-fifth acre.

Standard Plots.—All plots corresponding to the numbers 3, 6, 9, 10, 13, and 16 are called standard plots; that is, the variety, or whatever the test may be aside from soil treatment, is alike on all of these six plots for any one division.

Soil Treatment.—In order to maintain the productiveness of the field, fertilizing materials are applied and definite systems of crop rotation are employed

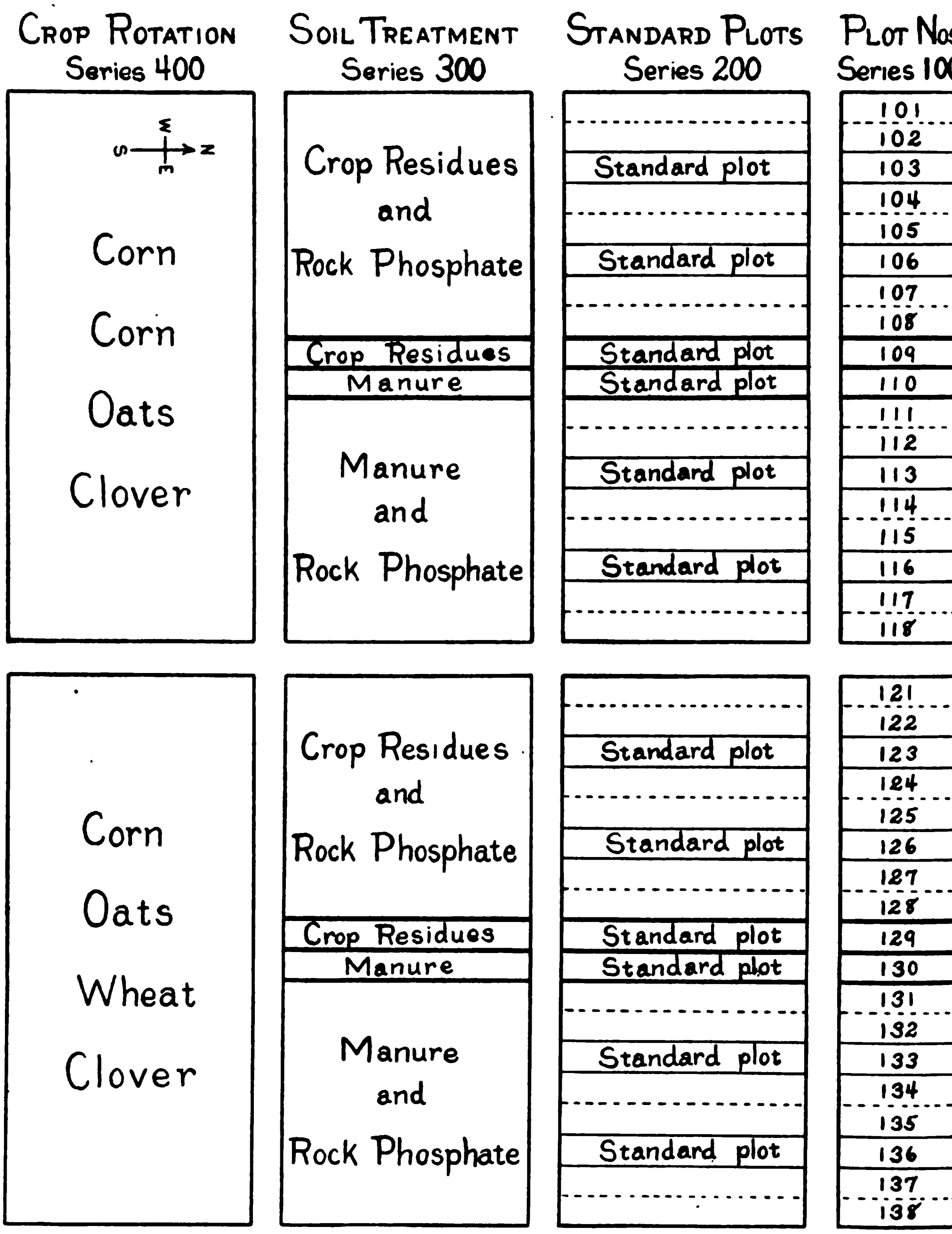


FIG. 4.—DIAGRAM OF DEKALB EXPERIMENT FIELD, SHOWING THE ARRANGEMENT OF PLOTS, THE SYSTEMS OF CROPPING, AND THE TREATMENTS APPLIED

as explained below, the crops being handled so as to exemplify the two systems of farming, grain and live stock. The plots comprizing the west half of each division represent grain farming. They receive no farm manure, but residues are returned to the soil. On the east half of each division, live-stock farming is represented, and here farm manure is applied in proportion to the crops produced. Raw rock phosphate is applied to all plots except the soil check plots (Nos. 9 and 10).

Soil Check Plots.—In the middle of every division two plots corresponding to the numbers 9 and 10 serve as check plots to test the effect of the phosphorus treatment. Plot 9 receives the crop residues produced and Plot 10 receives stable manure. Neither of these plots receives phosphate.

Rotation Systems.—The west half of the field, embracing the four west divisions of all four series, is farmed under a rotation of corn, corn, oats, and alsike clover. The east divisions of the series are in a rotation of corn, oats, wheat, and alsike clover. In the event of clover failure soybeans are substituted.

Tables 6 and 7 show the yield of each crop since the beginning of the experiments, and Table 8 gives a summary of these results, exclusive of those obtained in the beginning before full treatment was under way. Because of certain abnormalities in Plots 116 and 123 the data from these plots are excluded from the summary.

In looking over these records the beneficial effects of farm manure stand out prominently, thus emphasizing the importance of carefully conserving and regularly applying all available animal manures. Perhaps the fact next in interest to be noted is that the residues plots, with phosphorus applied, have returned yields almost as high as those from the manure plots. In considering this comparison it should be borne in mind that on these manure plots farm manure has been applied regularly at the rate of about 9 tons per acre every rotation, a practice quite impossible to carry out on every farm. It is possible, however, on every farm to sow clover and to return to the land the unconsumed crop residues, and this is the recourse for the farmer who cannot obtain animal manures in quantities sufficient to meet the demand of the land.

The profitable use of rock phosphate has been thoroly demonstrated on many farms in DeKalb county and if it seems surprising on first view that this material has not given greater returns on the DeKalb experiment field than the records show, the reader should take into full account the conditions involved as explained below.

In considering the results for rock phosphate on the DeKalb field, it should be explained at the outset that the soil of this field is considerably richer in phosphorus than the average brown silt loam, the analysis showing over 1,600 pounds per acre of this element in the surface stratum. A study of the summarized data shows some gain for rock phosphate in every crop excepting the clover seed in one of the crop rotation systems. In general these gains are more pronounced in the residues system than where applied with animal manure, which is not surprising since the manure itself carries back to the land a large share of the phosphorus removed in the grain.

It is to be observed further that phosphorus has been more effective in that rotation system which includes corn, oats, wheat, and clover than in the one

TABLE 6.—DEKALB FIELD: BROWN SILT LOAM PRAIRIE; EARLY WISCONSIN GLACIATION
ROTATION: CORN, OATS, WHEAT, CLOVER
Crop Yields—Bushels or (tons) per acre

Plot No.	Soil treatment applied	1906 Corn	1907 Oats	1908 Wheat	1909 Clover	1910 Corn	1911 Oats	1912 Oats	1913 Clover	1914 Corn	1915 Oats	1916 Wheat	1917 Clover	1918 Corn	1919 Oats	1920 Wheat
123	RP.......	67.4	30.0	27.7	0.00	48.2	15.0	42.3	0.00	81.5	49.8	35.2	0.00	58.8	47.7	31.8
126	RP.......	92.8	35.6	38.5	0.00	70.9	12.2	41.1	0.00	84.1	51.2	43.4	0.00	62.0	45.5	31.8
129	R........	67.3	33.4	37.3	0.00	63.9	18.1	55.9	0.00	61.3	40.7	35.1	0.00	57.2	41.4	26.6
130	M........	69.3	33.8	33.0	(.60)	61.1	17.6	64.6	(.92)	69.4	26.9	29.3	(.92)	57.3	41.1	28.5
133	MP......	76.8	39.1	43.0	(.90)	61.5	19.7	72.9	(1.96)	79.0	33.1	29.9	(.85)	57.0	38.8	36.8
136	MP......	72.0	35.0	41.8	(.90)	57.9	14.0	78.1	(1.96)	77.7	36.9	28.0	(.81)	57.0	42.7	36.8
		Oats	Wheat	Clover	Corn	Oats	Wheat	Soy-beans	Corn	Oats	Wheat	Clover	Corn	Oats	Wheat	Clover
223	RP.......	22.9	18.6	(2.92)	64.2	71.0	29.0	0.00	55.4	47.4	39.9	0.00	17.4	63.0	19.3	.50
226	RP.......	26.1	19.0	(2.90)	76.8	74.0	33.0	0.00	52.7	50.4	42.7	0.00	17.0	66.3	20.4	.70
229	R........	24.1	14.6	(2.32)	59.8	76.2	25.9	0.00	59.0	44.6	39.0	0.00	8.8	71.8	17.3	.90
230	M........	26.4	19.3	(2.55)	70.2	81.0	34.8	(1.40)	63.3	45.4	39.2	(2.25)	16.7	73.9	19.6	(2.30)
233	MP......	38.0	20.7	(2.67)	75.5	80.3	37.0	(1.40)	68.3	49.2	45.0	(2.56)	23.1	61.2	19.8	(2.46)
236	MP......	36.9	22.7	(2.45)	72.0	79.5	36.7	(1.90)	65.4	45.7	38.6	(2.56)	27.6	69.6	26.0	(2.24)
		Oats	Clover	Corn	Oats	Wheat	Clover	Corn	Oats	Wheat	Clover	Corn	Oats	Wheat	Clover	Corn
323	RP.......	27.9	(1.66)	55.9	70.1	31.2	0.00	67.2	57.4	39.0	0.00	48.6	87.0	24.4	2.91	56.0
326	RP.......	24.9	(1.66)	59.6	65.4	33.4	0.00	66.8	64.1	41.0	0.00	46.8	85.9	26.3	2.67	56.0
329	R........	25.4	(1.30)	39.2	73.3	25.6	0.00	54.4	54.0	25.4	0.00	38.5	80.7	21.1	2.50	43.4
330	M........	26.1	(1.30)	75.4	68.4	38.9	(.80)	69.9	66.4	33.5	(1.92)	50.7	77.1	20.4	(1.76)	61.4
333	MP......	22.8	(1.90)	67.1	74.6	39.0	(1.46)	67.9	71.9	37.2	(2.19)	52.6	78.3	22.2	(1.97)	57.4
336	MP......	23.6	(1.90)	72.6	67.3	45.9	(1.46)	66.8	71.7	39.5	(2.19)	54.7	74.5	29.0	(1.90)	57.4
		Soy-beans[1]	Corn	Oats	Oats	Clover	Corn	Oats	Wheat	Clover	Corn	Oats	Wheat	Clover	Corn	Oats
423	RP.......	....	43.9	36.2	61.4	0.00	81.0	81.3	35.4	3.29	32.4	68.8	25.4	1.24	70.1	80.7
426	RP.......	....	45.3	31.7	59.4	0.00	80.0	77.6	33.1	3.29	38.7	64.8	30.7	1.28	73.3	80.7
429	R........	....	43.5	37.3	66.1	0.00	76.4	77.8	27.7	4.50	30.9	62.5	25.2	1.33	62.3	68.8
430	M........	....	58.1	42.8	72.3	(3.10)	76.8	75.0	36.0	(2.68)	42.4	66.5	25.4	(2.21)	68.5	82.7
433	MP......	....	50.9	43.9	69.4	(3.08)	83.5	75.0	41.2	(3.05)	39.4	71.6	33.6	(2.68)	74.9	83.6
436	MP......	....	50.8	41.2	59.5	(3.08)	86.7	71.3	37.2	(3.05)	47.1	73.7	34.7	(2.56)	71.4	83.6

[1]Yields not taken.

TABLE 7.—DEKALB FIELD: BROWN SILT LOAM PRAIRIE; EARLY WISCONSIN GLACIATION
ROTATION: CORN, CORN, OATS, CLOVER
Crop Yields—Bushels or (tons) per acre

Plot No.	Soil treatment applied	1906 Corn	1907 Corn	1908 Oats	1909 Clover	1910 Corn	1911 Corn	1912 Oats	1913 Clover	1914 Corn	1915 Corn	1916 Oats	1917 Clover	1918 Corn	1919 Corn	1920 Oats
103	RP........	74.8	33.0	44.1	0.00	58.9	62.4	76.6	0.00	69.6	37.8	68.4	0.0	51.7	56.2	49.5
106	RP........	76.2	37.8	40.9	0.00	62.4	64.1	76.1	0.00	78.3	39.7	63.9	0.0	57.9	64.1	49.5
109	R........	73.0	35.3	44.1	0.00	55.7	54.5	63.1	0.00	68.4	33.3	62.1	0.0	47.1	56.1	50.2
110	M........	72.8	35.5	40.6	(1.80)	54.2	56.0	66.2	(1.26)	78.7	30.4	69.1	(.79)	55.0	52.8	63.8
113	MP........	66.0	30.4	45.6	(2.40)	58.6	59.3	74.1	(1.74)	76.9	39.6	66.6	(.59)	53.2	64.1	66.1
116[1]	MP........	51.6	0.0	28.1	(2.00)	45.2	0.0	60.5	(1.74)	79.7	33.3	54.4	(.52)	62.9	64.6	66.1
		Corn	Oats	Clover	Corn	Corn	Oats	Soy-beans	Corn	Corn	Oats	Clover	Corn	Corn	Oats	Clover
203	RP........	64.6	28.1	(2.45)	56.8	48.4	38.6	(.45)	58.3	50.4	68.5	0.00	17.2	51.3	62.1	2.90
206	RP........	66.6	28.7	(2.87)	47.1	45.2	39.2	(.90)	61.2	58.0	69.2	0.00	16.0	48.5	53.3	3.70
209	R........	76.4	30.3	(2.40)	59.2	53.9	37.8	(1.20)	68.4	64.9	61.4	0.00	16.9	46.3	60.1	2.80
210	M........	72.4	29.0	(2.60)	68.5	56.8	37.8	(1.10)	63.0	65.6	57.5	(1.84)	21.3	48.6	57.1	(1.94)
213	MP........	45.4	28.1	(2.25)	66.5	52.7	26.9	(0.00)[2]	64.1	62.8	54.0	(1.82)	19.4	46.0	52.7	(1.84)
216	MP........	76.0	28.9	(2.32)	63.0	46.4	27.0	(0.00)[2]	58.8	62.5	64.6	(1.82)	22.2	43.5	49.9	(1.67)
		Oats	Clover	Corn	Corn	Oats	Clover	Corn	Corn	Oats	Clover	Corn	Corn	Oats	Soy-beans	Corn
303	RP........	23.6	(1.38)	66.1	55.1	68.3	0.00	63.7	54.4	53.2	2.00	46.1	11.3	83.5	15.9	49.1
306	RP........	21.9	(1.38)	67.8	58.2	84.5	0.00	68.0	60.1	49.1	2.00	44.6	13.9	70.9	17.2	52.7
309	R........	25.3	(1.25)	66.0	58.2	76.1	0.00	57.6	59.1	47.7	3.70	43.4	9.0	79.7	16.9	46.0
310	M........	24.9	(1.45)	73.3	55.4	71.9	(1.30)	63.7	60.0	42.5	(1.59)	51.6	7.3	77.7	(1.26)	58.6
313	MP........	24.6	(1.69)	69.2	52.8	80.9	(1.50)	83.1	53.4	43.2	(1.88)	53.0	11.2	74.9	(1.28)	88.6
316	MP........	23.7	(1.69)	70.8	54.5	82.7	(1.50)	78.2	55.3	43.4	(1.88)	47.0	8.8	73.0	(1.54)	60.8
		Cow-peas[3]	Corn	Corn	Oats	Clover	Corn	Corn	Oats	Clover	Corn	Corn	Oats	Clover	Corn	Corn
403	RP........	....	53.0	43.9	37.5	0.00	78.6	52.4	43.2	3.12	40.5	40.3	67.5	1.49	56.6	44.9
406	RP........	....	54.9	46.5	43.8	0.00	75.8	60.2	43.6	3.12	44.0	45.7	78.6	1.42	55.4	50.1
409	R........	....	47.7	30.9	50.8	0.00	49.7	39.5	33.6	1.29	26.5	37.9	67.6	.61	48.7	42.6
410	M........	....	65.8	50.9	60.1	(2.44)	63.1	56.7	39.7	(2.54)	35.9	42.2	85.3	(1.51)	62.3	52.7
413	MP........	....	73.5	55.1	69.0	(3.41)	73.7	67.7	51.1	(3.32)	37.5	47.8	94.2	(1.96)	53.8	62.9
416	MP........	....	74.3	54.3	67.3	(3.41)	72.3	62.4	54.7	(3 32)	44 4	45.4	93.1	(1.83)	53.6	59.9

[1]Alkali spot. [2]Growth practically all weeds. [3]Yields not taken.

TABLE 8.—DE KALB FIELD: SUMMARY

Average Annual Yields—Bushels or (tons) per acre
1909–1920

Soil treatment applied	Crop rotation: corn, oats, wheat, clover				Crop rotation: corn, corn, oats, clover			
	Corn	Oats[1]	Wheat[2]	Clover[3]	Corn	Corn	Oats	Clover[3]
Residues, phos.	59.8	59.9	32.7	0.66	54.6	48.9	59.9	1.02
Residues	51.3	59.4	26.9	0.77	49.0	46.3	57.5	.94
Manure, phos.	61.7	62.4	34.7	(2.05)	59.0	50.9	63.2	(1.81)
Manure	59.0	61.4	30.6	(1.74)	56.3	48.7	60.7	(1.61)

[1]Average of 14 crops, oats being substituted when wheat failed.
[2]Average of 10 crops, oats being substituted when wheat failed.
[3]Soybean hay reckoned as equivalent to clover hay; soybean seed reckoned at 1/10 the equivalent of clover seed.

consisting of corn, corn, oats, and clover. In the former cropping system rock phosphate has returned a good financial profit reckoned at the prices prevailing during the years in which these results were obtained. In the latter rotation system, however, in which wheat does not appear, the gain from the increases in yield due to phosphate is just about offset by the expense involved. When considered from the standpoint of permanent fertility, however, the fact should not be overlooked that, in either system, thru the phosphate applications, the soil has not only been protected from loss of phosphorus in crops removed, but it has actually been enriched in this element by the excess provided in the liberal amount of phosphate used.

On the whole these results are of interest in indicating that there may exist here and there an exceptional spot of brown silt loam which, under all circumstances, will not respond in the usual striking manner to phosphorus treatment. In such an instance perhaps the more economical procedure would be to defer for a time phosphorus treatment in favor of more urgent needs of the land without ignoring the fact, however, that the time will inevitably come when the supply of phosphorus will become depleted unless timely provision be made for the replenishment of this element.

YELLOW-GRAY SILT LOAM

Yellow-gray silt loam exhibits an important variation with respect to limestone content. In some areas, altho limestone may be altogether absent in the surface stratum it is found in abundance at a short distance beneath the surface. Accordingly, variations in response to soil treatment are exhibited by different experiment fields located on this type. In view of this discrepancy it is thought well to introduce here the records of two fields, that are representative of the type but which show a marked diversity in results, one in northern Illinois and one in the southern part of the state.

The Antioch field is located on the late Wisconsin glaciation, in Lake county, close to the Wisconsin border. The field was started in 1902, with but a single series of ten plots, under a rotation of corn, corn, oats, and wheat; but beginning with 1911 the rotation has been wheat, corn, oats, and clover. It was started in order to learn as quickly as possible what effect would be produced by the addition to this type of soil of nitrogen, phosphorus, and potassium, used singly and in combination. These elements were all applied in commercial form until

1911, after which the use of commercial nitrogen was discontinued and crop residues were substituted in its place. Nitrogen was supplied in the earlier years in 800 pounds of dried blood per acre. Phosphorus is applied in 200 pounds of steamed bone meal, and potassium in 100 pounds of potassium sulfate. At the beginning, 470 pounds of slaked lime was applied; but since 1912 limestone has been applied at the rate of 1,000 pounds per acre per year.

Table 9 presents, in summarized form, the results from the Antioch field. Because of an abnormality in Plot 1, the results from this plot are not considered. The data show that phosphorus is the one element standing out prominently as producing consistently beneficial results. Potassium applied in addition to phosphorus has, on the whole, not produced profitable results. Also, the

TABLE 9.—ANTIOCH FIELD: YELLOW-GRAY SILT LOAM, TIMBER SOIL; LATE WISCONSIN GLACIATION

Average Annual Yields—Bushels or (tons) per acre
1902-1921

Serial plot No.	Soil treatment applied	Corn 8 crops	Oats 5 crops	Wheat 4 crops	Clover[1] 3 crops
1	0	23.9	32.3	15.8	1.33
2	L	21.3	26.8	13.2	1.26
3	LR	21.3	29.9	20.6	1.45
4	LP	30.7	43.6	36.7	1.61
5	LK	23.7	27.8	19.2	1.21
6	LRP	33.8	43.3	33.3	1.13
7	LRK	24.3	26.9	20.8	1.22
8	LPK	25.1	38.2	30.9	1.51
9	LRPK	38.3	42.6	28.0	1.00
10	RPK	38.4	44.7	30.2	1.28

[1] These figures represent the average combined yields of hay and seed, expressed as the equivalent of clover hay.

Lime applied and residues plowed under

Lime and phosphorus applied

FIG. 5.—CLOVER IN 1913 ON ANTIOCH FIELD

results are unfavorable for the application of limestone. Limestone, however, is abundant in the subsoil of this type in the region of this field.

The Raleigh experiment field is located on the lower Illinoisan glaciation, in southern Illinois, in Saline county. This field is laid out into four series of ten plots each, under a rotation of wheat, corn, oats, and clover. The treatments, along with the summarized results, are given in Table 10.

The outstanding feature of these results is the effect of limestone. Altho manure alone produces a substantial increase, especially in the corn crop, when

Manure, limestone, phosphorous
Yield: 61 bushels per acre

Nothing applied
Yield: 15 bushels per acre

FIG. 6.—CORN ON RALEIGH FIELD IN 1920

TABLE 10.—RALEIGH FIELD: YELLOW-GRAY SILT LOAM, TIMBER SOIL; LOWER ILLINOISAN GLACIATION

Average Annual Yields—Bushels or (tons) per acre
1911-1921

Serial plot No	Soil treatment applied	Corn 11 crops	Oats 11 crops	Wheat 7 crops	Legumes[1] 9 crops
1	0	15.8	10.2	6.2	(.42)
2	M	27.6	12.5	7.9	(.55)
3	ML	39 0	19 6	21.7	(1.14)
4	MLP	40 0	19 8	22.5	(1 36)
5	0	16.4	10.0	7.3	(.14)
6	R	19.4	12.8	8.8	(.19)
7	RL	34.3	21.2	19.7	(.71)
8	RLP	36 7	22 4	22 4	(.81)
9	RLPK	42 7	23 0	23.8	(.81)
10	0	20 2	11 2	6.9	(.30)

[1] These figures represent the average combined yields of clover and soybeans, whether hay or seed, expressed as the equivalnt of clover hay.

limestone is added a remarkable increase is found in all crops. A most important fact is that the organic matter can be effectively built up thru the use of crop residues, with the application of limestone, so that the crop yields are practically as high under this "grain system" of farming as where manure is used.

Phosphorus thus far has given only moderate returns in increased crop yields, but with an increasing quantity of organic matter and nitrogen it is probable that the phosphorus applications will show up more favorably on subsequent crops. As to the use of potassium, it is to be noted that aside from an increase of 6 bushels of corn in the residues system, the beneficial effect has not been sufficient to justify the use of this material.

In accounting for the discrepancy in the response to limestone on these two fields, the fact is to be considered that the Antioch field is located on the late Wisconsin glaciation, where the subsoil contains large quantities of limestone; while the Raleigh field represents the lower Illinoisan glaciation, the soil of which is very acid to a great depth.

In view of these variations, a general recommendation for a complete treatment for soil of this type, that will apply to all localities, cannot be given out until more information is acquired.

Fortunately, however, each farmer can determine for himself the need of limestone for his land by applying the simple tests for the presence of carbonates and soil acidity, as explained under the discussion of limestone on pages 28 and 29 of the Appendix.

Phosphorus, which has paid well on the Antioch field, and has given doubtful returns thus far at Raleigh, has varied considerably in its effect when used on other fields located on this same type of soil. In this situation, therefore, the present suggestion would be that each farmer might well try out phosphorus on his own land, on a limited scale, and be guided by the outcome of his experience. The low phosphorus content of the surface stratum of this soil is an indication that in a system of permanent agriculture the time is not far off when phosphorus will become a limiting element to crop production, and the wise farmer will watch carefully the indications and be ready to make timely provision for this need.

Deep Peat

As representing the deep peat type of soil, the results are introduced from an experiment field conducted at Manito in Mason county during the years 1902 to 1905 inclusive.

There were ten plots receiving the treatments indicated in Table 11.

The results of the four years' tests, as given in Table 11, are in complete harmony with the information furnished by the chemical composition of peat soil. Where potassium was applied, the yield was from three to four times as large as where nothing was applied. Where approximately equal money values of kainit and potassium chlorid were applied, slightly greater yields were obtained with the potassium chlorid, which, however, supplied about one-third more potassium than the kainit. On the other hand, either material furnished more potassium than was required by the crops produced.

TABLE 11.—MANITO FIELD: DEEP PEAT
Corn Yields—Bushels

Plot No.	Soil treatment for 1902	Corn 1902	Corn 1903	Soil treatment for 1904	Corn 1904	Corn 1905	Four crops
1	None	10.9	8.1	None	17.0	12.0	48.0
2	None	10.4	10.4	Limestone, 4000 lbs	12.0	10.1	42.9
3	Kainit, 600 lbs	30.4	32.4	Limestone, 4000 lbs.; Kainit, 1200 lbs	49.6	47.3	159.7
4	Kainit, 600 lbs.; Acidulat'd bone, 350 lbs.	30.3	33.3	Kainit, 1200 lbs.; Steamed bone, 395 lbs.	53.5	47.6	164.7
5	Potassium chlorid, 200 lbs	31.2	33.9	Potassium chlorid 400 lbs	48.5	52.7	166.3
6	Sodium chlorid, 700 lbs	11.1	13.1	None	24.0	22.1	70.3
7	Sodium chlorid, 700 lbs	13.3	14.5	Kainit, 1200 lbs	44.5	47.3	......
8	Kainit, 600 lbs	36.8	37.7	Kainit, 600 lbs	44.0	46.0	164.5
9	Kainit, 300 lbs	26.4	25.1	Kainit, 300 lbs	41.5	32.9	125.9
10	None	14.9[1]	14.9	None	26.0	13.6	69.4

[1]Estimated from 1903; no yield was taken in 1902 because of a misunderstanding.

The use of 700 pounds of sodium chlorid (common salt) produced no appreciable increase over the best untreated plots, indicating that where potassium is itself actually deficient, salts of other elements cannot take its place.

Applications of 2 tons per acre of ground limestone produced no increase in the corn crops, either when applied alone or in combination with kainit, either the first year or the second.

Reducing the application of kainit from 600 to 300 pounds for each two-year period reduced the yield of corn from 164.5 to 125.9 bushels. The two applications of 300 pounds of kainit (Plot 9) furnished 60 pounds of potassium for the four years, an amount sufficient for 84 bushels of corn (grain and stalks). Attention is called to the fact that this is practically the difference between the yield of Plot 9 (125.9 bushels) and the yield obtained from Plot 2 (42.9 bushels), the poorest untreated plot.

UNIVERSITY OF ILLINOIS

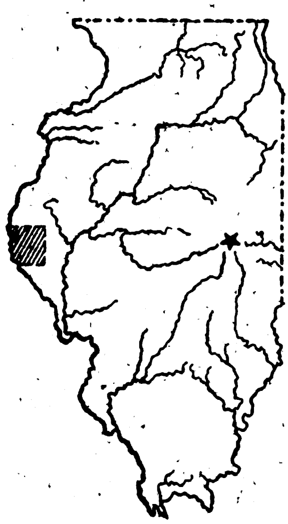
Agricultural Experiment Station

SOIL REPORT No. 24

ADAMS COUNTY SOILS

By J. G. Mosier, F. W. Wascher, W. R. Leighty,
and H. J. Snider

Prepared for Publication by L. H. Smith



URBANA, ILLINOIS, AUGUST, 1922

IN RECOGNITION

The Soil Survey of Illinois was organized under the supervision of the late Dr. Cyril G. Hopkins. The work progressed for eighteen years under his guidance and the first eighteen soil reports bear his name as senior author. On October 6, 1919, Dr. Hopkins died in a foreign land in the service of the American Red Cross. It is the purpose to carry on to completion this great work of the Illinois Soil Survey in the spirit, and along the same general plan and lines of procedure, in which it was begun.

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INTRODUCTORY NOTE

It is a matter of common observation that soils vary tremendously in their productive power, depending upon their physical condition, their chemical composition, and their biological activities. For any comprehensive plan of soil improvement looking toward the permanent maintenance of our agricultural lands, a definite knowledge of the various existing kinds or types of soil is a first essential. It is the purpose of a soil survey to classify the various kinds of soil of a given area in such a manner as to permit definite characterization for description and for mapping. With the information that such a survey affords, every farmer or land owner of the surveyed area has at hand the basis for a rational system of improvement of his land. At the same time the Experiment Station is furnished an inventory of the soils of the state, upon which intelligently to base plans for those fundamental investigations so necessary for solving the problems of practical soil improvement.

This county soil report is one of a series reporting the results of the soil survey which, when completed, will cover the state of Illinois. Each county report is intended to be as nearly complete in itself as it is practicable to make it, even at the expense of some repetition. There is presented in the form of an Appendix a general discussion of the important principles of soil fertility, in order to help the farmer and land owner to understand the significance of the data furnished by the soil survey and to make intelligent application of the same in the maintenance and improvement of the land. In many cases it will be of advantage to study the Appendix in advance of the soil report proper.

Data from experiment fields representing the more extensive types of soil, and furnishing valuable information regarding effective practices in soil management, are embodied in form of a Supplement. This Supplement should be referred to in connection with the descriptions of the respective soil types found in the body of the report.

CONTENTS OF SOIL REPORT NO. 24

ADAMS COUNTY SOILS

APPENDIX

SUPPLEMENT

ADAMS COUNTY SOILS

By J. G. MOSIER, F. W. WASCHER, W. R. LEIGHTY, AND H. J. SNIDER
PREPARED FOR PUBLICATION BY L. H. SMITH[1]

CLIMATE AND AGRICULTURAL PRODUCTION

Adams county is the most westerly county in Illinois. The south boundary is in a line with the geographical center of the state north and south; in other words, it is approximately 192 miles from the south line of Adams county to either end of the state. The county measures 30 miles north and south, and 32 miles east and west, embracing an area of about 850 square miles.

About one-fifth of the area of the county is bottom land, the major portion of which is included in the low lands of the Mississippi river. The upland in Adams county is occupied in larger part by timber soils and much of it is very rough and hilly. These hilly areas are interspersed by expanses of the more productive prairie soils.

The temperature of Adams county is characterized by a wide range between the extremes of summer and winter. The longest weather record in the county (which, however, covers but ten years) is at Quincy. The lowest temperature for this time was —20° in 1912 and 1918, while the highest was 108° in 1918, making for 1918 a range of 128 degrees, the greatest range for the ten years.

The average date of the last killing frost in spring is April 15; the earliest in fall, October 17. The growing season therefore is about 185 days long.

The average annual precipitation at Quincy from 1912 to 1921 was 33.78 inches. The average precipitation by months for this period was as follows: January, 1.65 inches; February, 1.31; March, 2.34; April, 3.46; May, 4.90; June, 4.92; July, 2.52; August, 3.25; September, 4.33; October, 2.16; November, 1.73; December, 1.28. The proportion of total rainfall occurring during each season was: winter, 12.5 percent; spring, 31.6 percent; summer, 31.6 percent; autumn, 24.3 percent. The year of heaviest rainfall in the ten years was 1915, when the precipitation was 48.17 inches; the driest year was 1912, when the rainfall was but 27.84 inches.

About 26 percent of the land in Adams county is better adapted to grazing than to the growing of ordinary tilled crops. In 1920, the census reported 3,844 farms, these farms having an average of 129.1 acres each, 97.1 acres of which were improved. Of these farms, 38.6 percent were operated by tenants, which was a decrease in tenantry of 5 percent in the last ten years.

The principal crops are corn, oats, wheat, rye, timothy, and clover. The Fourteenth Census of the United States (1920) reports the following as the acreage and yield of the more important crops. It must be remembered that these figures are for but a single year—that of 1919.

[1]J. G. Mosier, in charge of soil survey mapping; F. W. Wascher, in charge of field party; W. R. Leighty, in charge of soil analysis; H. J. Snider, in charge of experiment fields; L. H. Smith, in charge of publications.

Crops	Acreage	Production
Corn	94,498	3,594,497 bu.
Oats	45,498	1,403,422 "
Wheat	75,525	1,244,029 "
Rye	5,242	49,381 "
Soybeans	293	2,117 "
Timothy	11,286	12,615 tons
Timothy and clover mixed	19,246	21,257 "
Clover	7,882	7,822 "
Alfalfa	790	1,817 "
Silage crops	1,697	12,809 "
Corn for forage	9,844	18,807 "

The acreage of pasture is not given by the Census, but from other data it is found to be approximately 73,000.

The total value of the grains, hay, and seeds produced in 1919 was approximately 21⅓ million dollars.

The live-stock interests, including those of dairying, are of considerable importance, as shown by the following data taken from the Census of 1920.

Animals and animal products	*Number*	*Value*
Horses	17,741	$1,471,053
Mules	2,670	363,297
Beef cattle	23,947	1,341,454
Dairy cattle	15,853	983,385
Sheep	13,611	148,229
Swine	93,629	1,633,566
Poultry	90,329	381,791
Eggs and chickens	.....	1,040,876
Dairy products	.....	609,182
Wool	68,534 lbs.	37,567

Adams county is one of the great fruit-producing counties of the state, as shown by the following data:

Small fruit	
Strawberries	316,877 quarts
Raspberries	112,482 "
Blackberries and dewberries	20,969 "
Orchard fruit	
Apples	202,630 bushels
Peaches	1,712 "
Pears	13,734 "
Cherries	5,463 "
Grapes	140,626 pounds

SOIL FORMATION

The most important period in the geological history of the county, from the standpoint of soil formation, was the Glacial period, during which the material that later formed the soils was being deposited. At that time, snow and ice accumulated in the region of Labrador, west of Hudson Bay, and in the Rocky Mountains to such an amount that the mass pushed outward from these centers, especially southward, until a point was reached where the ice melted as rapidly as it advanced. As the ice advanced in these movements it buried everything, even the highest mountains, in its path. It would then recede slowly, and apparently normal conditions would be restored for a long period, after which another advance would occur. At least six of these great ice movements took place, each of which covered part of northern United States, altho the same parts were not covered every time.

000
200
500
800
1300
1400
1500

(a)

26

28

25.1
525.1

(b)

35

75
875

65

(c)

1528

1534

1564

(d)

1328

84
1354

(e)

2.
1421

1464

(f) 0

In advancing from the distant northern centers of accumulation, the ice gathered up all sorts and sizes of material, including clay, silt, sand, gravel, boulders, and even large masses of rock. Some of these materials were carried several hundred miles, and the coarser masses rubbed against the surface rocks or against each other until largely ground into rock powder, which now constitutes much of the soil. When, thru the melting of the ice, the limit of advance was reached, the material carried by the glacier was dropped, accumulating in a broad, undulating ridge or moraine, called a lateral moraine if formed at the side of the glacier, and a terminal moraine if formed at the end. If the ice melted more rapidly than the glacier advanced, the terminus of the glacier would recede, and the material would be deposited somewhat irregularly over the land, back of the moraines. Such a formation is known as a ground moraine. A glacier often would advance again, but not so far as before; or it would remain stationary, and another moraine would be built up. These moraines or ridges have a steep outward slope and a very gradual inward slope.

A pressure of forty pounds per square inch is exerted by a mass of ice one hundred feet thick, and these ice sheets may have been hundreds or even thousands of feet in thickness. The materials carried along in the ice, especially the boulders and pebbles, became powerful agents for grinding and wearing away the surface over which the ice passed. Preglacial ridges and hills were rubbed down, valleys were filled with the debris, and the surface features were changed entirely. The mixture of materials deposited by the glacier is known as boulder clay, till, glacial drift, or simply drift.

The material transported and deposited by a glacier varied with the character of the rocks over which it passed. Granites, limestones, sandstones, shales, etc., were encountered by the glacier, and both large and small masses of these were torn from their resting places by the enormous denuding power of the ice; they moved along with the glacier, were ground up more or less together, and were later deposited as the ice melted.

The names of the glaciers that had some part, either directly or indirectly, in the formation of the soils of Illinois are as follows: (1) The Nebraskan, which did not touch Illinois. (2) The Kansan, which covered parts of Hancock and Adams counties. The Yarmouth soil was developed from the surface of the Kansan glacial material. This soil was entirely covered by the next glacier. (3) The Illinoisan, which covered all of the state except the northwest corner (practically all of Jo Daviess county), the southern part of Calhoun county, and the seven southernmost counties. The Sangamon soil was formed from the surface of the Illinoisan drift. (4) The Iowan, which covered a part of northern Illinois. The area covered by this advance is difficult to determine because of the later glaciations. At about the close of the Iowan glacial advance, a wind deposit known as loess was laid down. The surface of this loess was formed into the Peorian soil, which was nearly all buried by the early Wisconsin glaciation. (5) The early Wisconsin glaciation, which covered the northeastern part of the state as far west as Peoria and south to Shelbyville. (6) The late Wisconsin glaciation, which extends to the west line of McHenry county and south to the town of Milford in Iroquois county.

THE GLACIATIONS OF ADAMS COUNTY

Only two of these glacial advances reached Adams county. The first was the Kansan, which came from the west or northwest, crossed the Mississippi river, and probably covered all except the southeast part of the county. A long period elapsed, the glacier melted, and a new soil was formed from the material deposited. Then another glacial advance occurred. This time the glacier (the Illinoisan) came from the northeast and covered the entire county, probably crossing the Mississippi river. It built up a moraine that extends diagonally across the county from southeast to northwest. This ridge, which was without doubt continuous at one time, has been divided by stream action into five short ridges which show very clearly the trend of the moraine. Another small ridge occurs about three miles east of the river at Quincy. Still another short moraine is found near Camp Point.

A later glacier, the Iowan, covered the northern part of the state, but did not reach Adams county. However, when it melted, large quantities of rock flour, or ground-up rock, were carried south and deposited on the flood plains of the rivers. From these flood plains the wind carried it on to the upland adjoining, making deposits varying in depth from 5 to 50 feet. This formation is called loess, and is made up largely of fine sand and still finer material (silt). The loess buried an old soil called the Sangamon soil.

The thickness of the glacial drift in Adams county varies from a few feet to 165 feet, but the average depth is not far from 65 feet. The deeper deposits represent an old pre-glacial valley which was filled with glacial drift or in which the drift was piled up in the form of a moraine. The deepest deposit found is near Coatsburg. Here a black soil two feet thick was encountered at a depth of 100 feet. This soil represents a period of normal conditions between glaciers, and is known as the Yarmouth soil, formed from Kansan drift.

The drift deposited by the Kansan glacier is in many places made up of a gray to yellow sand, while that left by the Illinoisan is a very heavy, compact clay with some gravel, usually of a blue color where the iron has not been oxidized. Very few boulders occur in the drift of either glacier.

Altho the county has been covered by glaciers, the glacial drift does not constitute any large part of the material from which the soils have been directly derived. A layer of wind-blown, or loessial, material that varies from four to twelve feet or more in thickness, constitutes the material from which the soil has been formed. The coarser material was deposited within four or five miles from the edge of the bottom land, giving the soil in those localities a fine sandy appearance. Often where much erosion has occurred, the loess has been all removed, in which case the soil may be formed from glacial drift, but this occurs only in small patches.

PHYSIOGRAPHY AND DRAINAGE

Adams county has extremes in topography. The northeast part of the county has large areas of extremely flat, and originally poorly drained land. The west and south parts have extensive areas of hilly, almost untillable land mixed with areas of undulating, tillable land.

The present topography is largely the result of erosion, glacial deposition being of secondary influence. Two distinct drainage basins occur in the

LEGE

R & W

000 Residu

200 Illinois

500 Upper

800 Deep L

300 Old B

400 Late S

500 Terrac

(a) UPLAN

26 Brown

28 Brown

26.1 525.1 Black

71 671 Brown

(b) UPLAN

Yellow

35 Yellow

Yellow

75 675 Yellow

65 Yellow

(c) 1500

Brown

Brown

1528 Brown

1534 Yellow

Yellow

1564 Yellow

(d) 1300

1328 Brown

54 354 Mixed

(e) 1400

Brown

Brown

Drab c

21 421 Drab c

Sandy

1454 Mixed

(f) 000 R

Rock

Small

MAP SHOWING THE DRAINAGE BASINS OF ADAMS COUNTY WITH MORAINAL, INTERMORAINAL, LOESSIAL, AND BOTTOM-LAND AREAS

county—those of the Mississippi and the Illinois rivers. The Mississippi basin is drained by Pigeon, Mill, and Bear creeks, the Illinois basin by McKees creek, and the northeast part of the county by tributaries of Crooked creek.

Following are the altitudes of some places in Adams county: Adams, 700 feet; Beverly, 856; Blacks, 728; Burton, 620; Camp Point, 740; Chattan, 715; Chestline, 740; Clayton, 744; Coatsburg, 769; Columbus, 732; Ewbanks, 733; Fair Weather, 839; Fall Creek, 451; Fowler, 733; Golden, 717; Kellerville, 730; La Prairie, 707; Lima, 620; Loraine, 644; Marblehead, 458; Mendon, 654; Paloma, 743; Payson, 726; Quincy, 488; Richfield, 735; Ursa, 588; Woodville, 664.

The highest point in the county is on the moraine in Section 34, southeast of Beverly, where the altitude is 858 feet. The Camp Point-Coatsburg ridge is 750 to 780 feet high; the ridge at Fowler, 700 to 750 feet. Low water in the Mississippi river at Quincy is 458 feet.

SOIL TYPES

About one-fifth of Adams county is bottom land and four-fifths upland. The soils, according to the survey, are divided into the following groups:

(a) Upland Prairie Soils, including the upland soils that have not been covered with forests—at least for any great length of time—and on which the luxuriant growth of prairie grasses has produced relatively large amounts of organic matter.

TABLE 1.—SOIL TYPES OF ADAMS COUNTY, ILLINOIS

Soil type No.	Name of type	Area in square miles	Area in acres	Percent of total area
	(a) Upland Prairie Soils (200, 500, 800)			
226, 526	Brown silt loam	102.71	65,734	12.11
228, 528	Brown-gray silt loam on tight clay	24.18	15,475	2.85
525.1	Black silt loam on clay	15.07	9,645	1.78
871	Brown fine sandy loam	20.89	13,370	2.46
		162.85	104,224	19.20
	(b) Upland Timber Soils (200, 500, 800)			
234, 534	Yellow-gray silt loam	232.19	148,602	27.38
235, 535	Yellow silt loam	181.13	115,923	21.36
874	Yellow-gray fine sandy loam	56.18	35,955	6.63
875	Yellow fine sandy loam	30.78	19,699	3.63
265, 565	Yellow sandy loam	8.37	5,357	.99
		508.65	325,536	59.99
	(c) Terrace Soils (1500)			
1526	Brown silt loam	.18	115	.02
1560	Brown sandy loam	.77	493	.09
1528	Brown-gray silt loam on tight clay	.20	128	.02
1534	Yellow-gray silt loam	2.18	1,395	.26
1536	Yellow-gray silt loam over gravel	.62	397	.07
1564	Yellow-gray sandy loam	.10	64	.01
		4.05	2,592	.47
	(d) Old Bottom-Land Soils (1300)			
1328	Brown-gray silt loam on tight clay	4.95	3,168	.58
1354	Mixed loam (small stream bottoms)	60.88	38,963	7.18
		65.83	42,131	7.76
	(e) Late Swamp and Bottom-Land Soils (1400)			
1426	Brown silt loam	33.95	21,728	4.00
1460	Brown sandy loam	6.54	4,186	.77
1415	Drab clay	8.68	5,555	1.02
1421	Drab clay loam	15.96	10,215	1.88
1421.1	Sandy drab clay loam	.30	192	.04
1454	Mixed loam (Mississippi overflow)	17.40	11,136	2.05
		82.83	53,012	9.76
	(f) Residual Soils (000)			
099	Rock outcrop	.41	262	.05
	Water	23.53	15,059	2.77
	Total	848.15	542,816	100.00

(b) Upland Timber Soils, including nearly all the upland areas that are now, or were formerly, covered with forests.

(c) Terrace Soils, including bench lands, or second bottom lands, formed by deposits from overloaded streams; and gravel outwash plains, formed by broad sheets of water arising from the melting of the glaciers.

(d) Old Bottom-Land Soils, including the low-lying land along streams other than the Mississippi river and formed of older materials than those of the late bottom lands.

(e) Late Swamp and Bottom-Land Soils, including the bottom lands of the Mississippi river and representing a newer formation than the old bottom lands.

(f) Residual, including rock-outcrop areas.

Table 1 gives a list of the types of soil found in Adams county, the area of each type in square miles and in acres, and also its percentage of the total area. The accompanying map shows the location and boundaries of each type of soil, even down to areas of a few acres.

For explanations concerning the classification of soils and the interpretation of the map and tables, the reader is referred to the first part of the Appendix.

INVOICE OF PLANT FOOD IN ADAMS COUNTY SOILS

SOIL ANALYSIS

The composition reported in the accompanying tables is, for the more extensive types, the average of several analyses. These analyses show that soils, like most things in nature, are variable; but for general purposes the average may be considered sufficient to characterize the soil type.

The chemical analysis of a soil, obtained by the methods here employed, gives the invoice of the total stock of the several plant-food materials actually present in the soil strata sampled and analyzed, but it should be understood that the rate of liberation, as explained in the Appendix (page 34), is governed by many factors.

For convenience in making practical application of the chemical analyses the results have been translated from the percentage basis and are presented here in terms of pounds per acre. In this, the assumption is made that for ordinary types, a stratum of dry soil 6⅔ inches thick weighs 2,000,000 pounds. It is recognized that this value is only an approximation, but it is believed that it will suffice for the purposes intended. It is, of course, a simple matter to convert these figures back to the percentage basis in case one desires for any purpose to consider the information in that form.

THE SURFACE SOIL

In Table 2 are reported the amount of organic carbon (which serves as a measure of the organic matter), and the total quantities of nitrogen, phosphorus, sulfur, potassium, magnesium, and calcium contained in 2 million pounds of the surface soil (the plowed soil of an acre about 6⅔ inches deep) of each type in Adams county.

TABLE 2.—PLANT FOOD IN THE SOILS OF ADAMS COUNTY, ILLINOIS: SURFACE SOIL
Average pounds per acre in 2 million pounds of surface soil (about 0-6⅔ inches)

Soil type No.	Soil type	Total organic carbon	Total nitrogen	Total phosphorus	Total sulfur	Total potassium	Total magnesium	Total calcium
	(a) Upland Prairie Soils (200, 500, 800)							
226, 526	Brown silt loam	47 090	3 630	1 000	720	32 490	5 270	8 860
228, 528	Brown-gray silt loam on tight clay	35 720	3 170	860	710	31 700	3 450	6 930
525.1	Black silt loam on clay	44 220	3 660	990	800	31 270	5 560	9 310
871	Brown fine sandy loam	36 610	3 080	1 020	530	35 090	6 520	9 580
	(b) Upland Timber Soils (200, 500, 800)							
234, 534	Yellow-gray silt loam	23 930	2 220	720	470	32 890	5 160	8 420
235, 535	Yellow silt loam	20 730	1 900	620	430	29 730	4 790	4 550
874	Yellow-gray fine sandy loam	25 700	2 380	850	530	33 720	5 390	9 550
875	Yellow fine sandy loam	15 920	1 500	600	340	29 600	6 600	7 800
265, 565	Yellow sandy loam	17 860	1 600	460	600	15 460	2 640	3 980
	(c) Terrace Soils (1500)							
1526	Brown silt loam	38 920	3 360	1 040	500	32 160	5 080	10 740
1560	Brown sandy loam	10 160	1 120	920	320	23 860	4 720	8 700
1528	Brown-gray silt loam on tight clay	16 780	1 960	800	500	29 120	5 020	9 300
1534	Yellow-gray silt loam	19 140	1 760	820	480	26 340	2 500	5 560
1536	Yellow-gray silt loam over gravel	18 140	2 140	860	440	33 580	5 060	9 900
1564	Yellow-gray sandy loam	12 900	1 520	620	460	22 400	3 280	7 640
	(d) Old Bottom-Land Soils (1300)							
1328	Brown-gray silt loam on tight clay	35 960	3 480	1 220	760	28 380	6 700	10 880
1354	Mixed loam	25 850	2 530	960	560	30 840	6 650	10 550
	(e) Late Swamp and Bottom-Land Soils (1400)							
1426	Brown silt loam	26 890	2 230	1 050	550	32 980	3 990	9 550
1460	Brown sandy loam	9 980	1 260	920	360	24 980	4 140	7 340
1415	Drab clay	36 410	3 240	1 320	710	32 170	8 630	10 700
1421	Drab clay loam	39 020	3 760	1 840	640	34 700	5 660	10 820
1421.1	Sandy drab clay loam	53 740	5 060	1 040	1 060	29 720	8 900	12 240
1454	Mixed loam	23 860	2 660	1 120	680	31 340	8 980	10 440

LIMESTONE AND SOIL ACIDITY.—In connection with these tabulated data it should be explained that the figures on limestone content and soil acidity are omitted not because of any lack of importance of these factors, but rather because of the peculiar difficulty of presenting in general averages adequate information concerning the limestone requirement. The limestone requirement for soils is extremely variable. It may vary from farm to farm, and even from field to field. Therefore no attempt is made to include in these tables figures purporting to represent for the various types the limestone content or the soil acidity present. The need for limestone should be determined on every farm and for each field individually. Fortunately this can be easily done by the simple tests described in the Appendix to this report, pages 36 and 37.

Because of the extreme variations frequently found within a given soil type with respect to the presence of limestone and acidity, no attempt is made to include in the tabulated results figures purporting to represent the average amounts of these substances present in the respective types. Such averages cannot give the farmer the specific information he needs regarding the lime requirements of a given field. Fortunately, however, very simple tests which

T

Soil type No.
226
526
228
528
525
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234
534
235
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875
265
565
152[illegible]
156[illegible]
152[illegible]
153[illegible]
153[illegible]
156[illegible]
132[illegible]
135
142
14[illegible]
141
14[illegible]
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14[illegible]

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TABLE 3.—PLANT FOOD IN THE SOILS OF ADAMS COUNTY, ILLINOIS: SUBSURFACE SOIL
Average pounds per acre in 4 million pounds of subsurface soil (about 6⅔-20 inches)

Soil type No.	Soil type	Total organic carbon	Total nitrogen	Total phosphorus	Total sulfur	Total potassium	Total magnesium	Total calcium
	(a) Upland Prairie Soils (200, 500, 800)							
226 526	Brown silt loam	67 390	5 230	1 740	1 090	66 530	13 400	16 450
228 528	Brown-gray silt loam on tight clay	42 460	3 480	1 360	920	64 380	12 780	15 800
525.1	Black silt loam on clay	57 980	4 740	1 400	1 200	63 120	12 380	18 600
871	Brown fine sandy loam	67 700	5 300	1 960	1 020	71 620	14 280	19 100
	(b) Upland Timber Soils (200, 500, 800)							
234 534	Yellow-gray silt loam	23 210	2 610	1 350	640	67 150	16 220	15 400
235 535	Yellow silt loam	14 520	1 770	1 000	600	54 270	12 480	6 630
874	Yellow-gray fine sandy loam	38 620	3 600	1 500	820	69 820	14 440	17 860
875	Yellow fine sandy loam	15 800	1 560	1 280	640	50 160	20 560	14 240
265 565	Yellow sandy loam	21 680	1 960	880	960	30 320	6 520	6 720
	(c) Terrace Soils (1500)							
1526	Brown silt loam	49 280	4 160	1 680	1 120	65 600	14 000	20 920
1560	Brown sandy loam	22 360	2 680	1 920	800	47 880	9 760	18 680
1528	Brown-gray silt loam on tight clay	26 400	3 280	1 600	840	59 360	9 360	19 040
1534	Yellow-gray silt loam	22 720	2 320	1 720	680	56 040	8 040	16 080
1536	Yellow-gray silt loam over gravel	15 520	2 640	1 640	640	71 120	13 120	17 600
1564	Yellow-gray sandy loam	16 560	1 840	1 120	560	46 640	7 720	14 360
	(d) Old Bottom-Land Soils (1300)							
1328	Brown-gray silt loam on tight clay	36 200	3 800	1 640	1 000	57 160	12 480	17 560
1354	Mixed loam	40 840	4 230	1 840	960	61 320	13 350	20 690
	(e) Late Swamp and Bottom-Land Soils (1400)							
1426	Brown silt loam	45 330	3 410	2 000	890	65 880	7 770	18 670
1460	Brown sandy loam	17 480	2 240	1 840	920	49 520	8 400	15 440
1415	Drab clay	42 540	4 240	2 000	840	63 140	15 300	19 680
1421	Drab clay loam	49 280	4 720	2 800	960	67 080	13 800	18 640
1421.1	Sandy drab clay loam	47 320	4 760	1 360	1 080	57 640	16 800	27 680
1454	Mixed loam	33 480	3 000	1 480	800	57 280	15 720	19 320

LIMESTONE AND SOIL ACIDITY.—See note in Table 2.

can be made at home will furnish this important information, and these tests are described on pages 36 and 37 of the Appendix.

Altho the variation among the different types of soil of Adams county with respect to the quantity of the plant food elements is not so extreme as is found in many other counties, nevertheless there are wide fluctuations, as a comparison of the figures in Table 2 will show. For example, it may be noted that one type of soil contains 4½ times the quantity of nitrogen as another (compare drab clay loam of the bottom lands with brown sandy loam of the terrace soils). The supply of phosphorus in the surface stratum of the different types varies, as it happens, in practically the same degree, the range being from 1,840 pounds per acre in the drab clay loam to 460 pounds in yellow sandy loam. A sulfur content of 340 pounds per acre is found in the yellow fine sandy loam, while

TABLE 4.—PLANT FOOD IN THE SOILS OF ADAMS COUNTY, ILLINOIS: SUBSOIL
Average pounds per acre in 6 million pounds of subsoil (about 20-40 inches)

Soil type No.	Soil type	Total organic carbon	Total nitrogen	Total phosphorus	Total sulfur	Total potassium	Total magnesium	Total calcium
	(a) Upland Prairie Soils (200, 500, 800)							
226, 526	Brown silt loam............	33 330	3 750	2 400	990	96 000	30 530	29 700
228, 528	Brown-gray silt loam on tight clay................	29 550	3 870	2 220	1 290	91 470	33 330	26 430
525.1	Black silt loam on clay......	38 940	3 600	2 040	930	89 010	37 260	29 850
871	Brown fine sandy loam......	42 990	4 320	2 700	1 080	105 810	30 420	29 670
	(b) Upland Timber Soils (200, 500, 800)							
234, 534	Yellow-gray silt loam.......	20 990	2 760	2 750	690	98 640	35 380	27 850
235, 535	Yellow silt loam............	14 800	2 220	1 360	1 320	75 240	20 320	9 060
874	Yellow-gray fine sandy loam.	22 080	2 880	3 060	1 140	98 580	31 470	29 040
875	Yellow fine sandy loam......	19 200	1 860	1 260	600	64 560	33 120	24 240
265, 565	Yellow sandy loam.........	24 000	2 940	1 080	900	55 140	14 880	9 780
	(c) Terrace Soils (1500)							
1526	Brown silt loam............	38 520	3 540	2 520	1 080	93 240	36 180	37 560
1560	Brown sandy loam..........	16 380	2 280	2 580	780	70 320	13 800	27 360
1528	Brown-gray silt loam on tight clay................	28 260	3 780	2 640	1 080	97 500	18 120	26 700
1534	Yellow-gray silt loam.......	17 760	2 280	2 880	780	82 440	23 520	25 440
1536	Yellow-gray silt loam over gravel..................	11 940	3 180	3 960	900	107 160	28 740	26 220
1564	Yellow-gray sandy loam.....	15 600	1 980	1 800	600	70 440	15 780	22 320
	(d) Old Bottom-Land Soils (1300)							
1328	Brown-gray silt loam on tight clay................	12 720	2 640	1 800	780	85 440	21 840	29 940
1354	Mixed loam................	30 920	3 500	1 880	1 300	83 640	18 420	27 020
	(e) Late Swamp and Bottom Land-Soils (1400)							
1426	Brown silt loam............	68 150	5 540	3 320	1 240	96 100	13 200	27 660
1460	Brown sandy loam..........	17 820	2 280	2 640	1 020	70 440	12 120	21 360
1415	Drab clay.................	36 720	4 050	2 250	1 020	86 370	24 630	41 610
1421	Drab clay loam............	19 860	3 660	3 240	1 140	97 020	13 080	30 480
1421.1	Sandy drab clay loam.......	29 640	3 660	3 240	1 140	90 120	23 160	36 720
1454	Mixed loam................	23 220	2 880	1 980	900	83 940	22 920	27 900

LIMESTONE AND SOIL ACIDITY.—See note in Table 2.

in the sandy drab clay loam there are 1,060 pounds of this element. The magnesium varies in the different types from 2,500 to 8,980 pounds, and the calcium content ranges from 620 to 12,240.

It is important to note that some of the plant-food elements are present in very limited quantities as compared with crop requirements. Some simple computations are of interest in this connection. Assume, for example, that a four-field crop rotation of wheat, corn, oats, and clover yields 50 bushels of wheat per acre, 100 bushels of corn, 100 bushels of oats, and 4 tons of clover hay. These are high yields, but not impossible, for they are sometimes obtained. It will be found that the most prevalent soil of Adams county, the yellow-gray silt loam, contains only enough total nitrogen in the plowed soil for the production of such yields to supply about four rotations.

With respect to phosphorus, the condition differs only in degree, this soil containing no more of that essential element than would be required for about ten crop rotations yielding at the rates suggested above. On the other hand, the amount of potassium in the surface layer of this common soil type is sufficient for more than 25 centuries if only the grain is sold, or for nearly 400 years if the total crops should be removed from the land and nothing returned.

These general statements relating to the total quantities of these plant-food materials in the plowed soil of the most prevalent type in the county certainly emphasize the fact that the supplies of some of these necessary elements of fertility are extremely limited when measured by the needs of large crop yields for even one or two generations of people.

THE SUBSURFACE AND SUBSOIL

In Tables 3 and 4 are recorded the amounts of plant food in the subsurface and the subsoil of the different types. It should be remembered, however, that these supplies are of little value unless the top soil is kept rich. These tables also show great stores of potassium in the prevailing types of soil but only limited amounts of nitrogen and phosphorus, in agreement with the data for the corresponding surface samples.

DESCRIPTION OF INDIVIDUAL SOIL TYPES

(a) UPLAND PRAIRIE SOILS

The upland prairie soils of Adams county cover an area of 162.85 square miles, or about one-fifth of the entire area of the county. They usually occupy the less eroded areas of the upland. They are black or dark brown in color, owing to their high organic-matter content. This land in its virgin condition was covered with prairie grasses, the partially decayed roots of which have been the principal source of the organic matter. The flat, poorly drained areas contain the greater amounts of organic matter, owing to the more luxuriant growth of the grasses there and to the excessive soil moisture which provided conditions better adapted for the preservation of their roots.

Brown Silt Loam (226, 526)

Brown silt loam is the third most extensive type in Adams county. It covers an area of 102.71 square miles, or 12.11 percent of the area of the county. It is widely distributed over the county, but the greatest area occurs in the four northeast townships.

This type occupies the slightly undulating to almost flat upland, some of which may at one time have been overspread for a short period by timber but not sufficiently long to have produced any marked change in the character of the soil. These forests consisted largely of black walnut, wild cherry, hackberry, ash, hard maple, and elm. A black walnut soil is recognized generally by farmers as being one of the best timber soils because of the fact that it still contains a large amount of organic matter, characteristic of prairie soils. After the growth of several generations of trees, the organic matter generally becomes so reduced that such a

soil would be classed as a timber type instead of a prairie type. In the southern and western parts of the county, the brown silt loam is confined to the divides that have not been dissected to any extent by the erosion of streams. The surface drainage is usually good, altho in a few cases in the northeastern part, artificial drainage is very desirable. The soil was formed from wind-blown loessial material which covers the county to a variable depth, usually more than three feet.

The surface soil, 0 to 6⅔ inches, is a brown silt loam varying on the one hand to black as it grades into black silt loam on clay (525.1), and on the other hand to brownish gray or grayish yellow as it grades into either brown-gray silt loam on tight clay (528) or yellow-gray silt loam (534). It contains a sufficient amount of the coarser constituents (coarse silt and fine sand) to make it work easily, and yet enough fine silt and clay to give it stability and cause it to granulate under proper conditions. It contains from 60 to 70 percent of silt, 10 to 15 percent of clay, and from 15 to 40 percent of sand, mostly fine. The organic-matter content varies from 3.5 to 4.5 percent, with an average of approximately 4.1 percent, or 41 tons per acre. There is less organic matter in the more rolling areas, and in places where the type grades into the timber soil. In the poorly drained parts, the larger moisture content encouraged a ranker growth of grasses and at the same time furnished more favorable conditions for the preservation of their roots.

The natural subsurface stratum is a silt loam varying in thickness from 6 to 12 inches and in color from a dark brown to a yellowish brown. Both color and depth vary with the topography, the type being lighter in color and shallower on the more rolling areas. The same effect is produced where the type grades into the timber soil. The subsurface as sampled (6⅔ to 20 inches) contains about 2.9 percent of organic matter, or 58 tons per acre.

The natural subsoil begins at a depth of 12 to 18 inches beneath the surface. It is a yellowish, drabbish, or grayish clayey silt or silty clay. It is somewhat plastic when wet, and has a tendency to be somewhat compact and more impervious than in most other areas of the state where the type occurs. Because of this condition, drainage does not take place so readily as in the type generally.

Management.—When the virgin brown silt loam was first cropped, the soil was in fine tilth, worked easily, and large crops could be grown with much less work than now. Continuous cropping, however, to corn or corn and oats with the burning of corn stalks, stubble, grass, and in many cases even straw, has destroyed the tilth in a great measure and now the soil is more difficult to work, washes badly, runs together, and bakes more readily. Unless the moisture conditions are very favorable, the ground plows up cloddy and unless well-distributed rains follow, a good seed bed is difficult to produce. The clods may remain all season. Much plant food is locked up in them and thus made unavailable, so that the best results cannot be obtained. This condition of poor tilth may become serious if the present methods of management continue; it is already one of the factors that limits crop yields. The remedy is to increase the organic-matter content by plowing under every available form of vegetable

material, such as farm manure, corn stalks, straw, clover, stubble, and even weeds.

The deficiency of organic matter in the soil is shown by the way the fall-plowed land runs together during the winter. Much more work is required to produce a seed bed than was formerly the case. The result is that corn is frequently planted in poorly prepared seed beds and as a consequence it "fires" badly. In the spring, fall-plowed land should be disked early and deeply for the purpose of conserving moisture, raising the temperature, and making plant food available.

The addition of fresh organic matter is not only of great value in improving the physical condition of this type of soil, but it is of even greater importance because of its nitrogen content and because of its power, as it decays, to liberate potassium from the inexhaustible supply in the minerals of the soil, and phosphorus from the phosphate contained in or applied to the soil.

For permanent, profitable systems of farming on brown silt loam, phosphorus should be applied liberally; and sufficient organic matter should be provided to furnish the necessary amount of nitrogen. On much of the type, limestone is already deficient. An application of 2 tons of limestone, and ½ ton of finely ground rock phosphate per acre every four years, with the return to the soil of all manure made from a rotation, will maintain the fertility of this type; altho heavier applications of phosphate may well be made during the first two or three rotations, and the first application of limestone may well be 4 tons per acre. If grain farming is practiced, the rotation may be wheat, corn, oats, and clover, with an extra seeding of clover (preferably sweet clover) as a cover crop in the wheat, to be plowed under late in the fall or in the following spring for corn; and most of the crop residues, including the clover chaff from the seed crops, should also be plowed under. In live-stock farming, the regular rotation may be extended to five or six years by seeding both timothy and clover with the oats, and pasturing one or two years. Alsike may well replace red clover at times, in order to avoid clover sickness. In either the grain or the live-stock system, alfalfa may be grown on a fifth field and moved every five years, the hay being fed or sold. Sweet clover is especially valuable on this type of soil because of its deep rooting habit and the effect that this has upon underdrainage.

For other suggestions regarding crop rotation systems, see page 42 of the Appendix. For results secured in field experiments on brown silt loam, see page 45 of the Supplement. On page 53 will be found a description of the experiment field located at Clayton in Adams county along with the results obtained.

Brown-Gray Silt Loam on Tight Clay (228, 528)

Brown-gray silt loam on tight clay is somewhat closely associated with brown silt loam and is widely distributed thruout the county. In topography it is usually flat—so much so that surface drainage is rather difficult. It covers an area of 24.18 square miles, or 2.85 percent of the area of the county.

The surface soil, 0 to 6⅔ inches, is a brown to grayish brown silt loam containing a perceptible amount of fine sand. This is quite evident after a

heavy rain, when the fine sand is washed out on to the surface. The organic-matter content is approximately 3.1 percent, or 31 tons per acre. As a general rule, this stratum does not contain quite so much clay as the average brown silt loam (526), and for this reason it is somewhat more pulverulent.

The natural subsurface is a silt loam varying in thickness from 6 to 12 inches and in color from brown to light gray. It is very low in organic matter. As a rule, the top two or three inches of the subsurface is a brown silt loam, while the lower portion of this stratum is gray. A considerable amount of coarse silt and fine sand is present. When dry, the stratum is decidedly gray. It is rather impervious to the downward movement of water, and so acts to some extent in preventing drainage. The subsurface as sampled (6⅔ to 20 inches) contains about 1.7 percent of organic matter, or 34 tons per acre.

The natural subsoil begins at a depth of 12 to 18 inches beneath the surface of the ground. It consists of a yellowish or brownish, compact, plastic, impervious clay, which renders drainage extremely difficult. As a rule, this impervious clay ends at 34 to 40 inches, and is followed by a yellow or grayish material much coarser in composition, quite friable, and not very plastic.

Management.—Much that was said in regard to the management of brown silt loam applies also to this type, especially in regard to organic matter. Methods should be undertaken for its permanent improvement. Frequently a farmer, instead of making improvement of a run-down soil, attempts to find a crop that will grow on it without improvement. As a result crops such as timothy are grown; and in some places, altho not in Adams county, redtop has been the crop of last resort. This is poor practice, since it only means a still further depletion of plant food.

After drainage, the first requirement in the improvement of this soil is limestone. Two to three tons per acre should be applied; this will put the soil in condition for the growing of legumes. The importance of legumes on this type of soil cannot be over-emphasized. They add nitrogen to the soil, and at the same time furnish a very valuable form of organic matter. The deep-rooting legumes open up the subsoil and allow better drainage; for this purpose sweet clover is especially desirable. All available organic matter, in any form, should be turned back into the soil. A half-ton of rock phosphate each rotation is very desirable as a means of building up the phosphorus content in which the type is deficient.

Black Silt Loam on Clay (525.1)

Black silt loam on clay is found almost exclusively in the northeastern four townships of the county, occurring on the flat and poorly drained areas. The type covers 15.07 square miles, or 1.78 percent of the total area of the county.

The surface soil, 0 to 6⅔ inches, varies from a black silt loam to a black clayey silt loam, some small areas even passing into a black clay loam. The surface stratum contains about 3.8 percent of organic matter, or 38 tons per acre.

The natural subsurface extends to a depth of 17 to 20 inches, and is usually heavier than the surface soil. It is black in color, becoming lighter with increas-

ing depth. This stratum as sampled (6⅔ to 20 inches) contains about 2.5 percent of organic matter, or 50 tons per acre.

The subsoil varies from a black to a pale yellow clay, very heavy and somewhat impervious.

Management.—Altho this type is fairly well supplied at present with organic matter and nitrogen, it is very desirable that these materials be maintained or even increased. This is especially true of the organic matter, which is necessary in order to keep the soil in good physical condition and maintain desirable working conditions. Crop residues, farm manure, and legumes should be turned under. The soil is becoming acid, and it will therefore be necessary, in order to provide for the best growth of legumes, to apply about 2 tons of limestone per acre. A very desirable form of legume for this type is sweet clover, as its deep-rooting habit opens up the subsoil and thus promotes better drainage.

This type is fairly well supplied with phosphorus, yet it would be desirable to begin to increase the content of this element by applying a half ton of finely ground rock phosphate per acre about once every four or five years.

Drainage is very necessary. As a rule, farmers have the impression that this type will not tile-drain. It is true that it will not drain so well as brown silt loam (526) and many other types, but by keeping it well supplied with limestone and growing deep-rooting legumes, there is no question but that it may be tile-drained satisfactorily.

Brown Fine Sandy Loam (871)

Brown fine sandy loam occurs as irregular patches on the western border of the upland, being confined within a strip about five miles wide along the Mississippi bluff line. The material from which it was made is derived from the bottom land of the Mississippi and has been carried and deposited upon the bluff by the wind. It is composed largely of fine sand and various grades of silt. The total area is 20.89 square miles, or 2.46 percent of the area of the county.

The surface soil, 0 to 6⅔ inches, is a brown fine sandy loam. It contains approximately 50 to 60 percent of fine sand, which gives it excellent working qualities and makes it well adapted for retaining moisture and moving it by capillarity. The organic-matter content is about 3.2 percent, or 32 tons per acre.

The natural subsurface of this type corresponds in depth to the standard sampling depth (6⅔ to 20 inches). It is a brown to yellowish brown, fine sandy loam, friable and pervious. The organic-matter content is about 2.8 percent.

The subsoil is a yellow, friable, pervious silt, containing a considerable percentage of fine sand.

Management.—This type is only fairly well supplied with the elements of plant food. It contains about 3,000 pounds of nitrogen per acre in the surface soil, and 1,000 pounds of phosphorus. The nitrogen will be used up more rapidly than the phosphorus and means should be taken to maintain or even increase the supply. Altho good crops may be grown in favorable years without paying much attention to nitrogen, yet the productiveness of the type may be decidedly increased by a little care in this regard. Farm manure, crop residues, and legumes are the means by which this element may be maintained or

increased, and the organic matter derived from these will enable the farmer to keep the soil in good tilth. There is, however, some acidity in the soil which always interferes with the growth of clover and alfalfa. In order to get the best results with legumes it is desirable even now that 2 or 3 tons of limestone per acre be applied and applications made often enough afterward to keep the soil in the best condition for growing legumes. The phosphorus content is somewhat low, and may well be increased by the application of a half-ton of rock phosphate for a number of rotations. Considered from the physical standpoint, there are very few soils in the state that are in better condition than this one; and every means should be employed to keep it up to its present standard.

(b) UPLAND TIMBER SOILS

The upland timber soils include nearly all the upland areas that are now, or have been, covered with forests. These soils contain much less organic matter than those of the prairie and hence are light brown, yellow, or gray in color. This difference is caused by the character of the vegetation that once covered them. In forests, the vegetable material (leaves and twigs from trees) accumulates upon the surface and is either burned or suffers almost complete decay. Grasses, which furnish large amounts of humus-forming roots, do not grow to any extent because of the shade of the trees. Moreover, the organic matter that had accumulated in the soil before the timber began growing is slowly removed thru various decomposition processes, with the result that in these timber soils generally the content of nitrogen and organic matter has become too low for the best growth of farm crops.

The total area of upland timber soils in Adams county is 508.65 square miles, or practically 60 percent of the area of the county.

Yellow-Gray Silt Loam (234, 534)

The yellow-gray silt loam is the most extensive type in the county, covering an area of 232.19 square miles, or 27.38 percent of the area of the county. It has been produced primarily by the long-continued growth of forests, which as a general rule developed along streams and slowly spread over the adjoining prairie. It varies in topography from flat to undulating and may be somewhat rolling where it passes into the eroded yellow silt loam (535).

The surface soil, 0 to 6⅔ inches, is a grayish yellow or brownish yellow silt loam containing from 20 to 35 percent of fine sand. It varies in physical composition to some extent, with the amount of erosion that has taken place, but in general it is quite uniform in its composition. It contains approximately 2 percent of organic matter, altho the amount of this element varies from about 1 percent, where much erosion has taken place, to 2.75 percent as it passes into the brown silt loam (-26).

The natural subsurface is from 5 to 12 inches thick and varies from a gray to a yellowish gray silt loam, passing into a clayey material. A decided change in color to that of gray usually occurs at a depth of 8 to 10 inches below the surface of the soil. The subsurface as sampled (6⅔ to 20 inches) contains approximately 1 percent of organic matter, or 20 tons per acre.

The natural subsoil begins at a depth of 12 to 18 inches. It is a yellow, grayish yellow, or brownish yellow clayey silt or silty clay that is usually rather plastic when moist.

Management.—The type is deficient in limestone, and low in organic matter, nitrogen, and phosphorus. As a rule, the soil is acid. The first requirement in its improvement is the correction of this acidity by the application of 2 to 4 tons of limestone per acre so that legumes may be grown satisfactorily. After this initial application, limestone should be applied often enough and in sufficient quantities to keep the soil in good condition for growing legumes. The condition of the soil with respect to acidity may easily be determined by making one of the tests described on pages 36 and 37.

The organic-matter and nitrogen contents are low, and since nitrogen is one of the elements contained in organic matter, any management that increases the organic-matter content will also increase the nitrogen. Crop residues, farm manures, and legumes should be turned into the soil. A rotation should be adopted that will provide for the frequent growing of legume crops. These should be largely turned under, or if fed the manure should be returned. Catch crops in grain may be used to advantage. By thus increasing the organic matter, the soil will be put in good tilth and in better condition to resist both drouth and excessive rains. The legumes that are grown are very important in another way. If the deep-rooting varieties are used, such as sweet clover, red clover, and alfalfa, the drainage conditions will be improved. Also the amount of run-off will be decreased because more water is absorbed during the rains and held in storage to serve during periods of drouth. Timothy, which is often grown as the principal crop on this kind of land, is not only of no benefit to the soil, but is actually a detriment. It would be much better to grow clover, or a mixture of clover and timothy.

The increase of the phosphorus content is very necessary. It would be well to apply from a half-ton to a ton of finely ground rock phosphate per acre once in each rotation until at least 2 or 3 tons per acre have been applied. On the more rolling parts of this type, washing is likely to occur, and here especially the organic-matter content should be increased and legumes grown. As a rule, the type does not require underdrainage, and yet there may be cases where it would be well to lay a tile in the draws to help prevent erosion.

For results from practical field experiments on yellow-gray silt loam, see page 57 of the Supplement.

Yellow Silt Loam (235, 535)

Yellow silt loam is very generally distributed over Adams county. It occurs mostly in very irregular areas as the broken and hilly land immediately adjoining the stream courses. It is very difficult to cultivate, and as a rule should be left in pasture. It is the second most extensive type in the county, covering a total of 181.13 square miles.

The surface soil, 0 to 6⅔ inches, is a yellow or brownish yellow silt loam which becomes somewhat gray upon drying after a shower. In some places erosion has exposed the yellow clayey subsoil. The stratum contains some fine

sand. The organic-matter content is low, there being about 1.8 percent, or only 18 tons per acre.

The natural subsurface is a yellow to grayish yellow silt loam, varying in thickness from 4 to 10 inches. This variation in depth is largely the result of erosion, and in some places the subsurface may be made up of the same material as the subsoil. The stratum sampled (6⅔ to 20 inches) contains about .6 percent of organic matter, or 12 tons per acre.

The natural subsoil is sometimes exposed on the surface in small patches where erosion has taken place, but it usually begins at a depth of 10 to 16 inches and is a yellow clayey silt or silty clay. In some places in part of its depth it partakes of the character of fine sandy loess, while in other places the subsoil to a depth of 40 inches may be made up of glacial till, which here is usually a heavy clay with some sand and fine gravel. It contains about .4 percent of organic matter.

Management.—Altho the total area of yellow silt loam is large, making up more than a fifth of the county, it is of little importance agriculturally because most of it is so hilly as to render its cultivation either extremely difficult or else impossible. It is therefore devoted almost entirely to pasture. Some areas might be cultivated were it not for the danger of loss from erosion. Even if the land is cleared and put under cultivation, its life under the ordinary methods of cultivation is only a few years. It then becomes practically unproductive. It is one of the most difficult soils in the state to manage.

This type in general is low in practically all the elements of plant food except potassium. It is also decidedly acid, particularly in the subsurface. With present methods it is of little use to apply plant food, because it would be washed away in a short time. It is, however, desirable to apply limestone at the rate of 3 or 4 tons per acre in order to furnish the best conditions for the growing of legumes, which are the best crops for preventing erosion. The amount of pasture produced on this hilly land may be greatly increased by the application of limestone and the growing of sweet clover. Sweet clover provides a large amount of excellent pasture and even the growth of blue grass will be greatly encouraged by the nitrogen that is furnished by the sweet clover. If the land is to be cultivated, sweet clover will add organic matter and will help to retain the soil. Thru the penetration of its roots it will loosen all strata of the soil so that much more water will be absorbed, thus preventing a large amount of run-off. The water that is absorbed into the soil is always of benefit, while that which runs off is always detrimental. All gullies that start in the field should be put under control at once. Probably the best way to do this is to fill them, apply limestone, and sow to sweet clover. A surface application of manure or straw may be necessary in order to prevent erosion until the sweet clover gets a start. (See Bulletin 207, Washing of Soils and Methods of Prevention). For methods of improving yellow silt loam, see the discussion of the Vienna experiment field on page 60 of the Supplement.

Yellow-Gray Fine Sandy Loam (874)

Yellow-gray fine sandy loam is found only in the deep loess area, which is within five miles of the Mississippi bluff. The topography is undulating to

slightly rolling. The total area is 56.18 square miles, or 6.63 percent of the area of the county.

The surface soil, 0 to 6⅔ inches, is a light brown to yellow fine sandy loam containing about 2.2 percent of organic matter, or 22 tons per acre.

The natural subsurface varies from 4 to 10 inches in thickness and is a yellow to a light brownish yellow fine sandy loam. The stratum as sampled (6⅔ to 20 inches) contains about 1.7 percent of organic matter, or 34 tons per acre.

The subsoil is a yellow fine sandy silt, friable and porous, and contains about .6 percent of organic matter.

Management.—This type is sufficiently undulating for good drainage. It is an excellent soil in its texture, but it is somewhat low in organic matter, nitrogen, and phosphorus. It is becoming acid, and if legumes are to be grown satisfactorily limestone must be applied at the rate of 2 to 3 tons per acre, the applications to be repeated as the soil requires. The growing and turning under of legumes, together with the farm manure and crop residues, will increase the content of organic-matter and nitrogen and will keep the soil in good physical condition.

It will soon be necessary to begin the application of phosphate, and this may give good results even now. Finely ground rock phosphate should be applied at the rate of a half-ton to a ton per acre every five or six years until the amount of phosphorus now present in the soil is almost doubled.

There are some places where washing will take place to an injurious extent unless measures are taken to prevent it. This can be largely prevented by growing legumes, by incorporating organic matter, and by keeping a cover crop on the land as much as possible.

Yellow Fine Sandy Loam (875)

Yellow fine sandy loam occurs in the deep loess area and along the stream courses. There is not so much eroded land in the sandy area along the streams in the western part of the county as is found in the more silty land along the streams in the eastern part. This is due, probably, to the greater porosity of the soil, which allows it to absorb moisture, and thus diminishes the run-off. The total area of this type is 30.78 square miles, or 3.63 percent of the area of the county. The topography is hilly and in many places very steep. This land should be cultivated only with the greatest care.

The surface soil, 0 to 6⅔ inches, is a yellow to light brownish yellow fine sandy loam containing about 1.4 percent of organic matter, or 14 tons per acre.

The subsurface soil, 6⅔ to 20 inches, is a yellow, slightly clayey silt containing about .7 percent of organic matter, or 14 tons per acre.

The subsoil is a yellow clayey silt containing .5 percent of organic matter.

Management.—The first requisite in the improvement of this type is the application of about 3 tons of limestone per acre. This soil is acid, especially in the surface and subsurface, and the limestone is necessary in order to correct the acidity and put the soil into condition for growing clovers. The content of nitrogen and organic matter is very low, and crop residues, legumes, and farm

manure should be turned under in order to increase these constituents. The total nitrogen content of the plowed soil is only 1,500 pounds per acre, which is entirely too low for profitable crops. It would be well to grow sweet clover or some other legume crop two or three years out of every four. Legumes may be grown as catch crops, even when the regular crop is grown. Sweet clover may be seeded in wheat and the year's growth turned under for corn; corn may be followed by soybeans, and that by wheat. Or any similar rotation may be used in which the legume is grown frequently.

The phosphorus content of the surface soil is only 600 pounds per acre; this should be augmented as rapidly as possible. The best plan is to apply a half-ton to a ton of finely ground rock phosphate per acre once in each rotation.

This type is better adapted to pasture than to anything else because of the difficulty of cultivation and of preventing washing. The suggestions which were made under yellow silt loam (535) for preventing washing will apply here also. See Bulletin 207, Washing of Soils and Methods of Prevention.

Yellow Sandy Loam (265, 565)

Yellow sandy loam occurs in eroded areas. There is a region in the southern part of the county in Townships 2 and 3 South, Ranges 6 and 7 West, in which the deeper subsoil is composed of sand. Where erosion has occurred, especially on the slopes, the sand is exposed, and this gives rise to the sandy loam type. The sand is either gray or bright yellow in color. The type covers an area of 8.37 square miles, or .99 percent of the total area of the county. In topography it is hilly and on the whole is very poor for agricultural purposes.

The surface soil, 0 to 6⅔ inches, is a yellow or brownish yellow sandy loam containing about 1.5 percent of organic matter, or 15 tons per acre. The sand is medium in grade and varies widely in amount.

The subsurface soil, 6⅔ to 20 inches, is a light brownish yellow to grayish yellow sandy loam containing about .9 percent of organic matter.

The subsoil is a reddish to grayish sand, usually much coarser than that of the surface. Sometimes this stratum contains a layer of grayish clay or a mixture of clay and sand.

Management.—The topography of this type prevents its being used to any extent for agricultural purposes other than pasturing. Even for this purpose it may be improved to a considerable extent by applications of limestone and rock phosphate. The soil is somewhat acid, and an application of 2 or 3 tons of limestone per acre should be made. The phosphorus content is very low, being only about 450 pounds per acre in the plowed soil, and in the subsurface and subsoil even less. Finely ground rock phosphate should be applied in amounts of about one-half to one ton per acre until the present phosphorus content in the surface soil is well built up. Acid phosphate may be used satisfactorily. The nitrogen content is low, amounting only to about 1,600 pounds per acre. To correct this condition, legumes should be grown and turned under, together with crop residues and farm manure.

(c) TERRACE SOILS

Terrace soils usually occur along streams. They were formed at a time when the streams, owing to melting glacier ice, were much larger than they are at present, and carried large amounts of coarse material, such as sand and gravel. Upon any decrease in their velocity, these overloaded streams deposited debris along their courses. This resulted in the partial filling of the valley and the formation of what are now the terraces, bench lands, or second bottom lands. Finer material later deposited over this sand and gravel forms the present soil. When the streams become reduced to their normal size after the glacier had melted, they began cutting down thru this deposit, and the beds of the streams are now so low that the terraces, or benches, do not overflow.

In Adams county, as a rule, the deposit of gravel or sand usually found in terraces is comparatively thin. It may be covered so deep by fine material (4 to 8 feet) as to have but little effect on drainage. The value of some terrace soils, however, is impaired by the nearness of the gravel to the surface, in which case the soil is unable to resist drouth. This difficulty, however, does not exist in Adams county. The total area of terrace lands in the county is only 4.05 square miles, or .47 percent of the area of the county.

Brown Silt Loam (1526)

The terrace brown silt loam occupies only .18 square miles, or 115 acres. It is found along Mill creek. The topography is slightly undulating.

The surface soil, 0 to 6⅔ inches, is a brown silt loam differing but little, except in origin, from that of the upland. It contains about 3.4 percent of organic matter, or 34 tons per acre.

The natural subsurface extends from a depth of 6⅔ to about 17 inches. It is a brown silt loam, becoming lighter in color with increasing depth. The stratum sampled (6⅔ to 20 inches) contains about 2.1 percent of organic matter, or 42 tons per acre.

The subsoil varies from a yellow clayey silt to a yellow silt. It is friable and porous, and contains about 1.1 percent of organic matter.

Management.—This type is practically the same as the upland brown silt loam (226 and 526) in its limestone, organic-matter, and phosphorus requirements and should be managed in essentially the same manner.

Brown Sandy Loam (1560)

The terrace brown sandy loam occurs in the Mississippi bottoms in Township 3 South, Range 8 West, and comprizes an area of 493 acres. It is elevated from 20 to 25 feet above the ordinary bottom land of the Mississippi. It is slightly undulating, as a result perhaps of wind action.

The surface soil, 0 to 6⅔ inches, is a brown sandy loam containing some coarse sand and fine gravel. The organic-matter content is about .9 percent, or only 9 tons per acre.

The subsurface soil, 6⅔ to 20 inches, is a brown sandy loam containing coarse sand and fine gravel. It differs from the surface soil in that it has slightly more organic matter (a content of 1 percent). This condition occasionally

occurs in sandy loams; there is a downward leaching of plant food from the surface to the subsurface, and consequently there is a greater accumulation of plant roots in the subsurface.

The subsoil is coarser than the subsurface stratum, containing more fine gravel. It is of a yellowish color.

Management.—About the only factor to be considered in the management of this soil for the present is the need of organic matter and nitrogen. In order to supply these elements, it may be necessary to apply limestone so that legumes may be grown more satisfactorily. After limestone is applied, alfalfa ought to grow well. A good supply of organic matter will tend to improve this soil in its power to retain moisture and will also prevent the sand particles from being so readily shifted by the wind.

Brown-Gray Silt Loam on Tight Clay (1528)

Brown-gray silt loam on tight clay occurs in a few small areas, the largest being along Mill creek. The total area amounts to but 128 acres. The topography is flat to slightly undulating.

The surface soil, 0 to 6⅔ inches, is a brown or grayish brown silt loam containing a small amount of sand. The organic-matter content is about 1.5 percent, or 15 tons per acre.

The subsurface soil, 6⅔ to 20 inches, is a gray to yellowish gray silt loam. It contains about 1.1 percent of organic matter.

The subsoil, 20 to 40 inches, varies from an ordinary gray silt to a clayey silt, becoming more clayey at a depth of 36 to 38 inches. The subsoil is not so compact and impervious as is the subsoil of the same type as it occurs in the upland.

Management.—This type in general is fairly well drained, but it is low in nearly all the elements of plant food. It therefore needs to be increased in organic matter and nitrogen, and for this purpose crop residues, farm manure, and legumes should be turned under. However, before the best results can be secured with clovers, it will be necessary to apply 2 to 3 tons of limestone per acre. Phosphorus should be applied at the rate of about one-half ton of finely ground rock phosphate per acre every four or five years. If this course is followed, a system will be established which in a few years will result in the growing of better crops and, at the same time, will put the soil in better tilth.

Yellow-Gray Silt Loam (1534)

Yellow-gray silt loam is found along Bear and Mill creeks. The individual areas are not large, but the total area amounts to 1,395 acres, or .26 percent of the area of the county. The topography is flat to undulating.

The surface soil, 0 to 6⅔ inches, is a gray to yellowish gray silt loam containing a perceptible amount of fine sand. It contains approximately 1.7 percent of organic matter.

The subsurface soil, 6⅔ to 20 inches, varies from a gray to a light gray silt loam. It contains about 1 percent of organic matter.

The subsoil, 20 to 40 inches, is a gray silt, changing to a silty clay at 22 to 24 inches.

Management.—The first requirement in the improvement of this soil is the application of 2 to 4 tons of limestone per acre. This should be followed by the incorporation of crop residues and barnyard manure, and by the growing of legumes. The legumes should not be removed from the land entirely, but should either be turned under or the manure produced from them should be saved and applied to the soil. Legumes are especially well adapted for benefiting this soil because of the fact that the roots will open up the subsoil and increase the facilities for drainage. Sweet clover is more desirable than any other legume except perhaps alfalfa. After a good crop of sweet clover has been grown, there will be little difficulty in getting alfalfa to take hold. The nitrogen content is only about 1,700 pounds per acre in the plowed soil, which is too low for a good productive soil, but the growing of legumes and the turning under of other forms of organic matter will soon increase the nitrogen content sufficiently. It would be well to apply a half-ton of rock phosphate per acre every four or five years for a number of rotations.

Yellow-Gray Silt Loam Over Gravel (1536)

Yellow-gray silt loam over gravel occurs particularly along Mill creek in the southern part of the county. In the formation of this type sufficient gravel has been deposited to furnish satisfactory drainage. The total area of the type is only 397 acres.

The surface soil, 0 to 6⅔ inches, varies from a light brown to a yellow-gray silt loam. It contains about 1.6 percent of organic matter, or 16 tons per acre.

The subsurface soil, 6⅔ to 20 inches, is a gray silt loam containing about .6 percent of organic matter, or 12 tons per acre.

The subsoil is a gray silt.

Management.—The drainage of this type is good. In other respects it requires essentially the same treatment as the preceding type (1534).

Yellow-Gray Sandy Loam (1564)

Only one area of yellow-gray sandy loam is found. It comprizes but 64 acres and is located in Section 10, Township 2 South, Range 8 West, along Mill creek. This type is low in all the elements of fertility and organic matter and is becoming decidedly acid. Essentially the same treatment should be applied to this soil as that recommended for yellow-gray silt loam (1534).

(d) OLD BOTTOM-LAND SOILS

The bottom lands of the state are divided into the old, or early-formed areas, and those that have been formed more recently. As a rule, the more recently formed areas have the best soil. This is especially true of those that are located in the bottom lands along the larger streams. Of the old bottom-land soils, Adams county has 65.83 square miles, classified under two types: brown-gray silt loam on tight clay (1328), and mixed loam (1354).

Brown-Gray Silt Loam on Tight Clay (1328)

Brown-gray silt loam on tight clay is found in the bottom lands of the Mississippi. It occupies a total area of 4.95 square miles, or .58 percent of the area of the county. The largest amount is in the region just south of Lima lake.

The surface soil, 0 to 6⅔ inches, is a brown or grayish brown silt loam containing about 3.1 percent of organic matter, or 31 tons per acre.

The subsurface soil, 6⅔ to 20 inches, is a brown silt loam changing at 8 to 10 inches to a gray silt loam that is somewhat impervious. It contains about 1.6 percent of organic matter.

The subsoil, 20 to 40 inches, is a gray silt with some brown iron mottlings. It contains about .4 percent of organic matter. A heavy, compact, stratum of clay occurs at a depth of about 36 inches.

Management.—The topography of this type is flat. It is therefore necessary to provide some form of drainage. The soil is of such a character that it will tile-drain fairly well. It is fairly well supplied with organic matter and nitrogen, but the present amounts must be maintained if the productiveness of the soil is to be continued. The type is becoming acid and will require the application of about 2 to 3 tons of limestone per acre in order to put it in the best condition for growing legumes. Crop residues should be turned under. It will probably not be necessary to apply phosphate at once, but a few years of cropping, especially since overflow is prevented by a levee so that there can be no deposition of soil material, will soon make the application of phosphorus necessary.

Mixed Loam (1354)

Mixed loam occurs along the small streams in the upland as narrow strips of bottom land which rarely exceed 100 rods in width. They are subject to frequent overflow but the water does not stay on long. Usually a large amount of sediment is carried, which is deposited to a greater or less extent over the flood plain. New channels are frequently developed, thus giving the type a slightly undulating topography. The soil varies widely, and for this reason it is impossible to separate it into distinct types based on physical composition. The total area in the county is 60.88 square miles, or 7.18 percent of the area of the county.

The surface soil, 0 to 6⅔ inches, varies from a sand to a brown silt loam, or even to a brown clayey silt loam. The next flood may entirely change the character of the soil, and it is therefore impossible to make a satisfactory classification, even on a very large scale. The organic-matter content of the sample taken was about 2.4 percent, or 24 tons per acre.

The subsurface soil, 6⅔ to 20 inches, is a brown mixed loam, varying in about the same way as the surface soil. It contains, as sampled, about 1.8 percent of organic matter.

The subsoil, 20 to 40 inches, varies from a brown or yellowish sand to a sandy silt loam. The subsoil presents as great or even greater variations than does the subsurface.

Management.—The type in general is kept fairly well supplied by overflow with the elements of plant food; about the only requirement that need be considered is good cultivation.

(e) LATE SWAMP AND BOTTOM-LAND SOILS

Six types of soil constitute the group designated as the late swamp and bottom lands. They occupy, all told, an area of 82.83 square miles, or nearly 10 percent of the area of the county.

Brown Silt Loam (1426)

The brown silt loam of the Mississippi bottoms (in which is included practically all of this type) is distributed along the length of the county inside of the levee. The topography is flat to slightly undulating. The total area in the county is 33.95 square miles.

The surface soil, 0 to 6⅔ inches, varies from a light brown to a dark brown silt loam. It frequently contains some fine sand that has been derived from the wind-blown material washed down from the upland. The organic-matter content is about 2.4 percent, or 24 tons per acre.

The subsurface soil, 6⅔ to 20 inches, is a light to very dark brown silt loam containing fine sand. It has an organic-matter content of 1.9 percent, or 38 tons per acre.

The subsoil, 20 to 40 inches, varies from a yellow to a brown silt loam, often containing more organic matter than either of the other strata. This is due to the fact that material has been deposited upon and has buried an old soil rich in organic matter. This condition is found especially when the type occurs near the bluff or near a stream from the bluff.

Management.—One of the greatest difficulties in the management of this type is to prevent overflow. Levees have been built along the Mississippi and along the larger streams from the upland, such as Bear, Mill, and Rock creeks. Even at the best, however, a levee will break occasionally and cause an overflow. The type is fairly well supplied with the elements of plant food; and as long as overflow continued, the deposits were sufficient to replace the plant food removed by cropping. Since this source of plant food no longer exists, it may be necessary in the course of time to begin the application of plant-food materials. The organic-matter content is not very high; and with its constant removal thru decomposition, steps should be taken looking to its maintenance and possibly to its increase. For this purpose, crop residues, farm manure, and legumes should be plowed under. This will increase the amount of organic matter, and so improve the tilth, and will increase also the amount of nitrogen. The phosphorus content, too, is rather low, and the application of that element will become necessary in time. By applying a half-ton of finely ground rock phosphate every four or five years, the phosphorus supply will be not only maintained but actually increased. The soil is becoming very low in limestone, and acidity is developing. Ground limestone should be applied in amounts depending upon the amount of acidity present.

Brown Sandy Loam (1460)

Brown sandy loam is distributed generally thruout the Mississippi bottom land. It covers an area of 6.54 square miles, or .77 percent of the area of the county. In topography it is flat to very slightly undulating.

The surface soil, 0 to 6⅔ inches, is a brown sandy loam with varying amounts of sand and organic matter, the latter averaging about .9 percent, or 9 tons per acre.

The subsurface soil, 6⅔ to 20 inches, is a brown sandy loam containing about .8 percent of organic matter.

The subsoil, 20 to 40 inches, is a slightly loamy yellow sand, mostly medium in grade.

Management.—The amount of sand in this type is sufficient to keep the soil in good workable condition. The organic-matter content is very low, which means also a low nitrogen content. The analyses show that this soil contains only about 1,200 pounds of nitrogen per acre in the surface stratum, which is far too low for a good, productive soil. In order to increase the content of organic-matter and nitrogen and to provide better physical conditions, legumes, farm manure, and crop residues should be turned under. The soil is becoming somewhat acid, and it may be necessary to apply 1 or 2 tons of crushed limestone per acre in order to get best results with clovers. The phosphorus content in the plowed soil is about 900 pounds per acre, which is probably sufficient for producing good crops on a soil of this texture. However, there is no question but that in a short time it will be necessary to apply phosphorus in some form. Probably the most economical form in which to apply it is that of finely ground raw rock phosphate; about one-half ton per acre should be applied in each rotation for several rotations.

Drab Clay (1415)

Drab clay is well distributed in the Mississippi bottoms, usually occurring some distance back from the river. It has been formed where there has been very little current, so that only the finest material has been carried in and deposited. The topography is flat. The formation taking place at present in Lima lake probably represents the method of formation of this type, altho such extensive lakes probably did not exist at the time this particular type was being formed. The total area of drab clay in the county is 8.68 square miles, or 1.02 percent of the area of the county.

The surface soil, 0 to 6⅔ inches, is a dark brown to light drab clay. It varies in physical composition, especially in the amount of sand present. Where this sand occurs in areas of sufficient size, it is mapped as sandy drab clay loam. The surface soil contains 3.1 percent of organic matter, or 31 tons per acre.

The subsurface soil, 6⅔ to 20 inches, is a drab clay, becoming slightly lighter in color with increasing depth. It varies in somewhat the same way as does the surface. It contains about 1.8 percent of organic matter, or 36 tons per acre.

The subsoil, 20 to 40 inches, is a drab clay. It contains about 1 percent of organic matter.

Management.—The great difficulty in the management of this type is found in its tendency to form clods, as a result of puddling. Fortunately, however, it possesses the property of granulation, without which cultivation would be practically impossible. Frequently when the land is plowed, it is cloddy, and a shower followed by drying will develop granulation, or the formation of crumbs, or, as it is frequently expressed, the soil "slakes." If the soil is worked at this time, it becomes mellow and is easily put into fine condition. The presence of limestone and organic matter aid in the process of granulation. A sufficient supply of these materials should be maintained for that purpose, as well as for their other beneficial effects. To furnish the requisite organic matter, crop residues and legumes should be turned under. This soil is fairly well supplied with the elements of plant food, altho the amount of nitrogen could well be increased. It is desirable that thoro cultivation be practiced in order to stimulate the process of nitrification, or the formation of available nitrates for the crop. Another essential factor calling for consideration in the management of this type is drainage. As a rule, this type in Adams county drains well, the only great difficulty being the securing of an outlet. Thru the process of checking or cracking, passage ways are developed in the soil which permit the ready movement of water. It would, however, be beneficial to the soil if deep-rooting legumes were grown. These would not only give a larger supply of nitrogen but would also open up the soil to a greater depth. The soil is becoming somewhat acid, and it may be necessary to apply 1 or 2 tons of limestone per acre in order to secure best results with legumes.

Drab Clay Loam (1421)

Drab clay loam is rather closely associated with drab clay and often grades into that type. It embraces 15.96 square miles or 1.88 percent of the total area of the county. Its origin is practically the same as that of the preceding type.

The surface soil, 0 to 6⅔ inches, is a light brown to a drab clay loam, varying toward a sandy phase on the one hand and toward a drab clay on the other. It contains about 3.3 percent of organic matter, or 33 tons per acre.

The subsurface soil, 6⅔ to 20 inches, is a brown to drab heavy clay loam. It contains approximately 2.1 percent of organic matter, or 42 tons per acre.

The subsoil, 20 to 40 inches, varies in color from light to dark drab and in texture from a clayey silt to a silty clay.

Management.—This type is a little better provided with nitrogen and phosphorus than the drab clay, but its management should be about the same as for that type. It is becoming acid and in a few years, if not at the present time, the application of a ton or two of limestone per acre will be necessary in order to get the best results with legumes. This is especially true since the building of the levees, which have largely prevented overflow. Good cultivation is essential for this type also. The property of granulation is very desirable and should be encouraged by good drainage and the supplying of limestone and organic matter.

Sandy Drab Clay Loam (1421.1)

Sandy drab clay loam occurs in a few small areas in different parts of the Mississippi bottom land. The total area covered is 192 acres. It passes into drab clay loam (1421).

The surface soil, 0 to 6⅔ inches, is a dark drab sandy clay loam containing about 4.6 percent of organic matter, or 46 tons per acre.

The subsurface soil, 6⅔ to 20 inches, is also a dark drab sandy clay loam with the sand distributed somewhat in strata, indicating perhaps the effect of different periods of overflow. This subsurface stratum contains about 2 percent of organic matter.

The subsoil is very similar in character to the subsurface.

Management.—The management as discussed for the two preceding types will apply here also.

Mixed Loam (1454)

Mixed loam is found in the Mississippi bottoms and comprizes the area outside of the levee. It is of very little importance agriculturally, except on part of Long island, which is under cultivation. There is always danger of overflow, and whenever this occurs changes are produced in the character of the soil. At one time the soil deposited may be a heavy clay, while at other times in the same region it may be almost pure sand. The total area of this type is 17.40 square miles, or 2.05 percent of the area of the county.

The type is usually well supplied with plant food. Altho it is not very high in food elements, yet the deposit of new material from overflow is sufficient to maintain the supply of plant food indefinitely.

APPENDIX

EXPLANATIONS FOR INTERPRETING THE SOIL SURVEY

CLASSIFICATION OF SOILS

In order to intelligently interpret the soil maps, the reader must understand something of the method of soil classification upon which the survey is based. Without going far into details the following paragraphs are intended to furnish a brief explanation of the general plan of classification here used.

The unit in the soil survey is the soil type, and each type possesses more or less definite characteristics. The line of separation between adjoining types is usually distinct, altho sometimes one type grades into another so gradually that it is very difficult to draw the line between them. In such exceptional cases, some slight variation in the location of soil-type boundaries is unavoidable.

In establishing soil types several factors must be taken into account. These are: (1) the geological origin of the soil, whether residual, cumulose, glacial, eolial, alluvial, or colluvial; (2) the topography, or lay of the land; (3) the native vegetation, as prairie grasses or forest; (4) the depth and the character of the surface, the subsurface, and the subsoil, as to the percentages of gravel, sand, silt, clay, and organic matter which they contain, their porosity, granulation, friability, plasticity, color, etc.; (5) the natural drainage; (6) the agricultural value, based upon its natural productiveness; (7) the ultimate chemical composition and reaction.

Great Soil Areas in Illinois.—On the basis of the first of the above mentioned factors, namely, the geological origin, the state of Illinois has been divided into seventeen great soil areas with respect to their geological formation. The names of these areas are given in the following list along with their corresponding index numbers, the use of which is explained below. For the location of these geological areas, the reader is referred to the general map published in Bulletins 123 and 193.

000 *Residual,* soils formed in place thru disintegration of rocks, and also rock outcrop
100 *Unglaciated,* comprizing three areas, the largest being in the south end of the state
200 *Illinoisan moraines,* including the moraines of the Illinoisan glaciations
300 *Lower Illinoisan glaciation,* covering nearly the south third of the state
400 *Middle Illinoisan glaciation,* covering about a dozen counties in the west-central part of the state
500 *Upper Illinoisan glaciation,* covering about fourteen counties northwest of the middle Illinoisan glaciation
600 *Pre-Iowan glaciation,* but now believed to be part of the upper Illinoisan
700 *Iowan glaciation,* lying in the central northern end of the state
800 *Deep loess areas,* including a zone a few miles wide along the Wabash, Illinois, and Mississippi rivers
900 *Early Wisconsin moraines,* including the moraines of the early Wisconsin glaciation
1000 *Late Wisconsin moraines,* including the moraines of the late Wisconsin glaciation
1100 *Early Wisconsin glaciation,* covering the greater part of the northeast quarter of the state
1200 *Late Wisconsin glaciation,* lying in the northeast corner of the state
1300 *Old river-bottom and swamp lands,* found in the older or Illinoisan glaciation
1400 *Late river-bottom and swamp lands,* those of the Wisconsin and Iowan glaciations
1500 *Terraces,* bench or second bottom lands, and gravel outwash plains
1600 *Lacustrine deposits,* formed by Lake Chicago, the enlarged glacial Lake Michigan

Mechanical Composition of Soils.—The mechanical composition, or the texture, is a most important feature in characterizing a soil. The texture depends upon the relative proportions of the following physical constituents:

Organic matter: undecomposed and partially decayed vegetable material
Inorganic matter: clay, silt, fine sand, sand, gravel, stones

Classes of Soils.—Based upon the relative proportion of the various constituents mentioned above, soils may be grouped into a number of well recognized classes. Following is a list of these classes, arranged according to their index numbers, the use of which is explained below:

Index Number Limits	Class Names
0 to 9	Peats
10 to 12	Peaty loams
13 to 14	Mucks
15 to 19	Clays
20 to 24	Clay loams
25 to 49	Silt loams
50 to 59	Loams
60 to 79	Sandy loams
80 to 89	Sands
90 to 94	Gravelly loams
95 to 97	Gravels
98	Stony loams
99	Rock outcrop

Naming and Numbering Soil Types.—The naming of soil types has been the subject of much discussion, and practice varies considerably in this matter. In this soil survey of Illinois a system of classification and naming has been adopted which is based upon the various considerations presented in the preceding paragraphs.

After texture, one of the most striking characteristics of a soil is the color. Therefore, in the naming of soils in Illinois, a combination of color and texture, together with other descriptive terms when necessary, has been adopted so that the name in itself carries a definite description of a given soil type; as for example, "gray silt loam on tight clay," or "brown silt loam over gravel." The use of the prepositions *on* and *over* serves to indicate the presence of certain substrata. When the surface soil is underlain with material such as sand, gravel, or rock, the word *over* is used if this material lies at a depth greater than 30 inches; if it is less than 30 inches, the word *on* is used.

For further identification of soil types a system of numbering, resembling somewhat the Dewey library system, has been adopted whereby each soil type is assigned a certain number. This number indicates at once the geological origin of the soil as well as its physical description. The digits of the order of hundreds represent the geological area where the soil is found, beginning with 000, the residual, followed by 100, the unglaciated, and the rest of the series in the order of the enumeration presented in the paragraph above headed *Great Soil Areas in Illinois*. The digits of the orders of units and tens represent the various kinds of soil such as are enumerated above in the list of soil classes. Certain modifications are designated in this system by a figure placed at the right of the decimal point. To illustrate the working of this numbering system, suppose a soil type bears the number 726.5. The number 7 indicates that this soil occurs in the Iowan glaciation, the 26 that it is a brown silt loam, and the .5 that rock

is found less than 30 inches below the surface. These numbers are especially useful in designating small areas on the map and as a check in reading the colors.

A complete list of the soil types occurring in each county, along with their corresponding type numbers and the area covered by each type, will be found in the respective county soil reports.

SOIL SURVEY METHODS

Mapping the Soil Types.—In conducting the soil survey, the county constitutes the unit of working area. In order that the survey be thoroly trustworthy it is necessary that careful, well-trained men be employed to do the mapping. The work is prosecuted to the best advantage by working in parties of from two to four. Only such men are placed in charge of these parties as are thoroly experienced in the work and have shown themselves to be especially well qualified in training and ability.

The men must be able to keep their location exactly and to recognize the different soil types, with their principal variations and limits, and they must show these upon the maps correctly. A definite system is employed in checking up this work. As an illustration, one man will survey and map a strip 80 rods or 160 rods wide and any convenient length, while his associate will work independently on another strip adjoining this area, and if the work is correctly done the soil-type boundaries will match up on the line between the two strips.

An accurate base map for field use is absolutely necessary for soil mapping. The base maps are prepared on a scale of one inch to the mile, the official data of the original or subsequent land survey being used as a basis in their construction. Each surveyor is provided with one of these base maps, which he carries with him in the field; and the soil-type boundaries, together with the streams, roads, railroads, canals, and town sites are placed in their proper locations upon the map while the mapper is on the area. Each section, or square mile, is divided into 40-acre plots on the map, and the surveyor must inspect every ten acres and determine the type or types of soil thereon. The different types are indicated on the map by different colors, pencils for this purpose being carried in the field.

A small auger 40 inches long forms for each man an invaluable tool with which he can quickly secure samples of the different strata for inspection. An extension for making the auger 80 inches long is taken by each party, so that any peculiarity of the deeper subsoil layers may be studied. Each man carries a compass to aid in keeping directions. Distances along roads are measured by a speedometer or by some other measuring device, while distances in the field away from the roads are determined by pacing, an art in which the men become expert by practice. The soil boundaries can thus be located with as high a degree of accuracy as can be indicated by pencil on the scale of one inch to the mile.

Sampling for Analysis.—After all the soil types of a county have been located and mapped, samples representative of the different types are collected for chemical analysis. For this purpose usually three strata are sampled; namely, the surface (0 to 6⅔ inches), the subsurface (6⅔ to 20 inches), and the subsoil

(20 to 40 inches). These strata correspond approximately, in the common kinds of soil, to 2,000,000 pounds of dry soil per acre in the surface layer, and to two times and three times this quantity in the subsurface and the subsoil, respectively. This is, of course, a purely arbitrary division, very useful in arriving at a knowledge of the quantity and the distribution of plant food in the soil, but it should be noted that these strata do not necessarily coincide with the natural strata as they actually exist in the soil, and which are referred to in describing the soil types.

By this system of sampling we have represented separately three zones for plant feeding. The surface layer includes at least as much soil as is ordinarily turned with the plow. This is the part with which the farm manure, limestone, phosphate, or other fertilizer applied in soil improvement is incorporated, and which must be depended upon in large part to furnish the necessary plant food for the production of crops. A rich subsoil has little or no value if it lies beneath a worn-out surface, but if the fertility of the surface soil is maintained at a high point, then the strong vigorous plants will have power to secure more plant food from the subsurface and subsoil.

PRINCIPLES OF SOIL FERTILITY

Probably no agricultural fact is more generally known by farmers and landowners than that soils differ in productive power. Even tho plowed alike and at the same time, prepared the same way, planted the same day with the same kind of seed, and cultivated alike, watered by the same rains and warmed by the same sun, nevertheless the best acre may produce twice as large a crop as the poorest acre on the same farm, if not, indeed, in the same field; and the fact should be repeated and emphasized that with the normal rainfall of Illinois the productive power of the land depends primarily upon the stock of plant food contained in the soil and upon the rate at which it is liberated, just as the success of the merchant depends primarily upon his stock of goods and the rapidity of sales. In both cases the stock of any commodity must be increased or renewed whenever the supply of such commodity becomes so depleted as to limit the success of the business, whether on the farm or in the store.

CROP REQUIREMENTS

Ten different elements of plant food are essential for the growth and formation of every plant. These elements are: *carbon, oxygen, hydrogen, nitrogen, phosphorus, sulfur, potassium, magnesium, calcium, and iron;* and they are represented by the chemical symbols: C, O, H, N, P, S, K, Mg, Ca, and Fe. Some seasons in central Illinois are sufficiently favorable to allow the production of at least 50 bushels of wheat per acre, 100 bushels of corn, 100 bushels of oats, and 4 tons of clover hay. When such crops, growing under favorable climatic and cultural conditions and uninjured by disease or insect pests, are not produced the failure is due to unfavorable soil condition, which may result from poor drainage, poor physical condition, or from an actual deficiency of plant food.

Table A shows the plant-food requirements of some of our most common field crops with respect to the seven elements furnished by the soil. The figures show the weight in pounds of the various elements contained in a bushel or in a

TABLE A.—PLANT FOOD IN WHEAT, CORN, OATS, AND CLOVER

Produce		Nitrogen	Phosphorus	Sulfur	Potassium	Magnesium	Calcium	Iron
Kind	Amount							
		lbs.	*lbs.*	*lbs.*	*lbs.*	*lbs.*	*lbs.*	*lbs.*
Wheat, grain......	1 bu.	1.42	.24	.10	.26	.08	.02	.01
Wheat, straw.....	1 ton	10.00	1.60	2.80	18.00	1.60	3.80	.60
Corn, grain.......	1 bu.	1.00	.17	.08	.19	.07	.01	.01
Corn stover.......	1 ton	16.00	2.00	2.42	17.33	3.33	7.00	1.60
Corn cobs........	1 ton	4.00	.....	.....	4.00	.....	.....	.....
Oats, grain.......	1 bu.	.66	.11	.06	.16	.04	.02	.01
Oat straw........	1 ton	12.40	2.00	4.14	20.80	2.80	6.00	1.12
Clover seed.......	1 bu.	1.75	.50	.....	.75	.25	.13	.....
Clover hay.......	1 ton	40.00	5.00	3.28	30.00	7.75	29.25	1.00

ton, as the case may be. From these data the amount of any element removed from an acre of land by a crop of a given yield can easily be computed.

It needs no argument to show that the continuous removal of such quantities of plant food without provision for their replacement must result sooner or later in soil depletion.

PLANT-FOOD SUPPLY

Of the ten elements of plant food, three (*carbon, oxygen,* and *hydrogen*) are secured from air and water, and seven from the soil. *Nitrogen,* one of these seven elements obtained from the soil by all plants, may also be secured from the

TABLE B.—PLANT-FOOD ELEMENTS IN MANURE, ROUGH FEEDS, AND FERTILIZERS

Material	Pounds of plant food per ton of material		
	Nitrogen	Phosphorus	Potassium
Fresh farm manure..............................	10	2	8
Corn stover..............................	16	2	17
Oat straw..............................	12	2	21
Wheat straw..............................	10	2	18
Clover hay..............................	40	5	30
Cowpea hay..............................	43	5	33
Alfalfa hay..............................	50	4	24
Sweet clover (water-free basis)[1]......................	80	8	28
Dried blood..............................	280	...	...
Sodium nitrate..............................	310	...	...
Ammonium sulfate..............................	400	...	...
Raw bone meal..............................	80	180	...
Steamed bone meal..............................	20	250	...
Raw rock phosphate..............................	...	250	...
Acid phosphate..............................	...	125	...
Potassium chlorid..............................	...	...	850
Potassium sulfate..............................	...	...	850
Kainit..............................	...	...	200
Wood ashes[2]..............................	...	10	100

[1]Young second year's growth ready to plow under as green manure.
[2]Wood ashes also contain about 1,000 pounds of lime (calcium carbonate) per ton.

air by one class of plants (legumes), in case the amount liberated from the soil is insufficient; but even these plants (which include only the clovers, peas, beans, and vetches among our common agricultural plants) are dependent upon the soil for the other six elements (*phosphorus, potassium, magnesium, calcium, iron,* and *sulfur*), and they also utilize the soil nitrogen so far as it becomes soluble and available during their period of growth.

The vast difference with respect to the supply of these essential plant food elements in different soils is well brought out in the data of the Illinois soil survey. For example, it has been found that the nitrogen in the surface 6⅔ inches, which represents the plowed stratum, varies in amount from 180 pounds per acre to nearly 33,000 pounds. In like manner the phosphorus content varies from about 420 to 4,900 pounds, the potassium ranges from 1,530 to about 58,000 pounds. Similar variations are found in all of the other essential plant food elements of the soil.

With these facts in mind it is easy to understand how a deficiency of one of these elements of plant food may become a limiting factor of crop production. When an element becomes so reduced in quantity as to become a limiting factor of production, then we must look for some outside source of supply. Table B is presented for the purpose of furnishing information regarding the quantity of plant food contained in some of the materials most commonly used as sources of plant-food supply.

LIBERATION OF PLANT FOOD

The chemical analysis of the soil gives the invoice of fertility actually present in the soil strata sampled and analyzed, but the rate of liberation is governed by many factors, some of which may be controlled by the farmer, while others are largely beyond his control. Chief among the important controllable factors which influence the liberation of plant food are the choice of crops to be grown, the use of limestone, and the incorporation of organic matter. Tillage, especially plowing, also has a considerable effect in this connection.

Feeding Power of Plants.—Different species of plants exhibit a very great diversity in their ability to obtain plant food directly from the insoluble minerals of the soil. As a class, the legumes—especially such biennial and perennial legumes as red clover, sweet clover, and alfalfa—are endowed with unusual power to assimilate from mineral sources such plant foods as calcium and phosphorus, converting them into available forms of food for the crops that follow. For this reason it is especially advantageous to employ such legumes in connection with the application of limestone and rock phosphate. Thru their growth and subsequent decay large quantities of the mineral foods are liberated for the benefit of the cereal crops which follow in the rotation, and which are less independent feeders. Moreover, as an effect of the deep rooting habit of these legumes, large quantities of mineral plant foods are brought up and rendered available from the vast reservoirs of the lower subsoil.

Effect of Limestone.—Limestone corrects the acidity of the soil and thus encourages the development not only of the nitrogen-gathering bacteria which live in the nodules on the roots of clover, cowpeas, and other legumes, but also the nitrifying bacteria, which have power to transform the insoluble and unavailable organic nitrogen into soluble and available nitrate nitrogen. At the

same time, the products of this decomposition have power to dissolve the minerals contained in the soil, such as potassium and magnesium, and also to dissolve the insoluble phosphate and limestone which may be applied in low-priced forms. Thus, in the conversion of sufficient organic nitrogen into nitrate nitrogen for a 100-bushel crop of corn, the nitrous acid formed is alone sufficient to convert seven times as much insoluble tricalcium phosphate into soluble monocalcium phosphate as would be required to supply the phosphorus for the same crop.

Organic Matter and Biological Action.—Organic matter may be supplied by animal manures, consisting of the excreta of animals and usually accompanied by more or less stable litter; and by plant manures, including green-manure crops and cover crops plowed under, and also crop residues such as stalks, straw, and chaff. The rate of decay of organic matter depends largely upon its age, condition, and origin, and it may be hastened by tillage. The chemical analysis shows correctly the total organic carbon, which constitutes, as a rule, but little more than half the organic matter; so that 20,000 pounds of organic carbon in the plowed soil of an acre corresponds to nearly 20 tons of organic matter. But this organic matter consists largely of the old organic residues that have accumulated during the past centuries because they were resistant to decay, and 2 tons of clover or cowpeas plowed under may have greater power to liberate plant food than the 20 tons of old, inactive organic matter. The history of the individual farm or field must be depended upon for information concerning recent additions of active organic matter, whether in applications of farm manure, in legume crops, or in sods of old pastures.

The condition of the organic matter of the soil is indicated to some extent by the *ratio of carbon to nitrogen.* Fresh organic matter recently incorporated with the soil contains a very much higher proportion of carbon to nitrogen than do the old resistant organic residues of the soil. The proportion of carbon to nitrogen is higher in the surface soil than in the corresponding subsoil, and in general this ratio is wider in highly productive soils well charged with active organic matter than in very old, worn soils badly in need of active organic matter.

The organic matter furnishes food for bacteria, and as it decays certain decomposition products are formed, including much carbonic acid, some nitrous acid, and various organic acids, and these acting upon the soil have the power to dissolve the essential mineral plant foods, thus furnishing soluble phosphates, nitrates, and other salts of potassium, magnesium, calcium, etc., for the use of the growing crop.

Effect of Tillage.—Tillage, or cultivation, also hastens the liberation of plant food by permitting the air to enter the soil. It should be remembered, however, that tillage is wholly destructive, in that it adds nothing whatever to the soil, but always leaves it poorer, so far as plant food is concerned. Tillage should be practiced so far as is necessary to prepare a suitable seed bed for root development and also for the purpose of killing weeds, but more than this is unnecessary and unprofitable; and it is much better actually to enrich the soil by proper applications of limestone, organic matter and other fertilizing materials, and thus promote soil conditions favorable for vigorous plant growth, than to depend upon excessive cultivation to accomplish the same object at the expense of the soil.

PERMANENT SOIL IMPROVEMENT

According to the kind of soil involved, any comprehensive plan contemplating a permanent system of agriculture will need to take into account some of the following considerations.

The Application of Limestone

The Function of Limestone.—In considering the application of limestone to land it should be understood that this material functions in several different ways, and that a beneficial result may therefore be attributable to quite diverse causes. Limestone provides the plant food calcium, of which certain crops are strong feeders. It corrects acidity of the soil, thus making for some crops a much more favorable environment as well as establishing conditions absolutely required for some of the beneficial legume bacteria. It accelerates nitrification and nitrogen fixation. It promotes sanitation of the soil by preventing the growth of certain fungus diseases, such as corn root rot. Experience indicates that it modifies either directly or indirectly the physical structure of fine-textured soils, frequently to their great improvement.

Thus, working in one or more of these different ways, limestone often becomes the key to the improvement of worn lands. Remarkable success has been experienced with limestone used in conjunction with sweet clover in the reclamation of abandoned hill land which had been ruined thru erosion.

Amounts to Apply.—If the soil is acid, usually at least 2 tons per acre of ground limestone should be applied as an initial treatment. Continue to apply limestone from time to time according to the requirement of the soil as indicated by the tests described below, or until the most favorable conditions are established for the growth of legumes, using preferably at times magnesian limestone ($CaCO_3MgCO_3$), which contains both calcium and magnesium and has slightly greater power to correct soil acidity, ton for ton, than the ordinary calcium limestone ($CaCO_3$). On strongly acid soils, or on land being prepared for alfalfa, 4 or 5 tons per acre of ground limestone may well be used for the first application.

How to Ascertain the Need for Limestone.—The need of a soil for limestone may be ascertained by applying one of the following tests for soil acidity. Along with the acidity test, a test for the presence of carbonates should be made. It should be understood that a positive test for carbonates does not guarantee the absence of acid; for it may happen, especially when the soil is near the neutral point, that positive tests for both acidity and carbonates are obtained. This condition is explained by the assumption that solid particles of calcium or magnesium carbonates form centers of alkalinity within a soil that is generally acid. Because of this fact any test made of a given soil ought to be repeated if it is to be thoroly reliable. It is also desirable to test samples from different depths. Following are the directions for making these tests:

The Litmus Paper Test for Acidity. Make a ball of fresh moist soil, break it in two, insert a piece of blue litmus paper, and press the soil firmly together. After a few minutes examine the paper. If it has turned pink or red, soil acidity is indicated. The intensity of the color and the rapidity with which it develops indicates to some extent the amount of acidity. Needless to say the reliability of the test depends upon the quality of litmus paper used.

The Potassium Thiocyanate Test for Acidity. A more recently discovered test for soil acidity which promises to be more satisfactory than the litmus test is made with a 4-percent solution of potassium thiocyanate in alcohol—4 grams of potassium thiocyanate in 100 cubic centimeters of 95-percent alcohol (not denatured). When a small quantity of soil shaken up in a test tube with this solution gives a red color the soil is acid and limestone should be applied. If the solution remains colorless the soil is not acid. The conditions for a prompt reaction require a temperature that is comfortably warm.

The Hydrochloric Acid Test for Carbonates. Make a shallow cup of a ball of soil and pour into it a few drops of concentrated hydrochloric acid. If carbonates are present they are decomposed with the liberation of carbon dioxid, which appears as gas bubbles, producing foaming or effervescence. With much carbonate present the action is lively, but with mere traces of it the bubbles are given off slowly. If no carbonate, or very little, is indicated by the test, then it is advisable to apply limestone.

The Nitrogen Problem

Nitrogen presents the greatest practical soil problem in American agriculture. Four important reasons for this are: its increasing deficiency in most soils; its cost when purchased on the open market; its removal in large amounts by crops; and its loss from soils thru leaching. Nitrogen costs from four to five times as much per pound as phosphorus. A 100-bushel crop of corn requires 150 pounds of nitrogen for its growth, but only 23 pounds of phosphorus. The loss of nitrogen from soils may vary from a few pounds to over one hundred pounds per acre, depending upon the treatment of the soil, the distribution of rainfall, and the protection afforded by growing crops.

An inexhaustible supply of nitrogen is present in the air. Above each acre of the earth's surface there are about sixty-nine million pounds of atmospheric nitrogen. The nitrogen above one square mile weighs twenty million tons, an amount sufficient to supply the entire world for four or five decades. This large supply of nitrogen in the air is the one to which the world must eventually turn.

There are two methods of collecting the inert nitrogen gas of the air and combining it into compounds that will furnish products for agricultural uses. *These are the chemical and the biological fixation of the atmospheric nitrogen.* Farmers have at their command one of these methods. By growing inoculated legumes, nitrogen may be obtained from the air, and by plowing under more than the roots of those legumes, nitrogen may be added to the soil.

Inasmuch as legumes are worth growing for feed and seed as well as for nitrate production, a considerable portion of the nitrogen thus gained may be considered a by-product. Because of that fact, it is questionable whether the chemical fixation of nitrogen, the possibilities of which now represent numerous compounds, will ever be able to replace the simple method of obtaining atmospheric nitrogen by growing inoculated legumes.

For easy figuring it may well be kept in mind that the following amounts of nitrogen are required for the produce named:

1 bushel of oats (grain and straw) requires 1 pound of nitrogen.
1 bushel of corn (grain and stalks) requires 1½ pounds of nitrogen.
1 bushel of wheat (grain and straw) requires 2 pounds of nitrogen.
1 ton of timothy contains 24 pounds of nitrogen.
1 ton of clover contains 40 pounds of nitrogen.
1 ton of cowpeas contains 43 pounds of nitrogen.
1 ton of alfalfa contains 50 pounds of nitrogen.
1 ton of average manure contains 10 pounds of nitrogen.
1 ton of young sweet clover, at about the stage of growth when it is plowed under as green manure, contains, on water-free basis, 80 pounds of nitrogen.

The roots of clover contain about half as much nitrogen as the tops, and the roots of cowpeas contain about one-tenth as much as the tops. Soils of moderate productive power will furnish as much nitrogen to clover (and two or three times as much to cowpeas) as will be left in the roots and stubble. In grain crops, such as wheat, corn, and oats, about two-thirds of the nitrogen is contained in the grain and one-third in the straw or stalks.

The Phosphorus Problem

The element phosphorus is an indispensable constituent of every living cell. It is intimately connected with the life processes of both plants and animals, the nuclear material of the cells being especially rich in this element.

The phosphorus content of a soil varies according to its origin and the kind of farming practiced. Even virgin soils are found that are deficient in phosphorus.

On all lands deficient in phosphorus (except on those susceptible to serious erosion by surface washing or gullying) that element should be applied in considerably larger amounts than are required to meet the actual needs of the crops desired to be produced. The abundant information thus far secured shows positively that finely ground natural rock phosphate can be used successfully and very profitably, and clearly indicates that this material will be the most economical form of phosphorus to use in all ordinary systems of permanent, profitable soil improvement. The first application may well be one ton per acre, and subsequently about one-half ton per acre every four or five years should be applied, at least until the phosphorus content of the plowed soil reaches 2,000 pounds per acre, which may require a total application of from 3 to 5 or 6 tons per acre of raw phosphate containing 12½ percent of the element phosphorus.

Steamed bone meal and even acid phosphate may be used in emergencies, but it should always be kept in mind that a pound of phosphorus delivered in Illinois in the form of raw phosphate (direct from the mine in carload lots), is much cheaper than the same amount in steamed bone meal or in acid phosphate, both of which cost too much per ton to permit their common purchase by farmers in carload lots, which is not the case with raw phosphate. Landowners should bear in mind the fact that phosphorus additions to the soil in amounts above the immediate crop requirements represent a permanent investment, since this element is not readily lost in the drainage water as in the case of nitrogen. It is removed from the farm thru the sale of crops, milk, and animals.

Phosphate may be applied at any time during a rotation, but it is applied to the best advantage either preceding a crop of clover, which plant seems to possess an unusual power for assimilating raw phosphate, or else at a time when it can be plowed under with some form of organic matter such as animal manure or green manure, the decay of which serves to liberate the phosphorus from its insoluble condition in the rock. It is important that the finely ground rock phosphate be intimately mixed with the organic material as it is plowed under.

The Potassium Problem

Normal soils, in which clay and silt form a considerable part of the constituency, are well stocked with potassium, altho it exists largely in insoluble

form. Such soils as sands and peats, however, are likely to be low in this element. On such soils this deficiency may be supplied by the application of some potassium salt, such as potassium sulfate, potassium chlorid, kainit, or other potassium compound, and in many instances this is done at great profit.

From all the facts at hand it seems, so far as our great areas of normal soils are concerned, that the potassium problem is not one of addition but of liberation. The Rothamsted records, which represent the oldest soil experiment fields in the world, show that for many years other soluble salts have had practically the same power as potassium to increase crop yields in the absence of sufficient decaying organic matter. Whether this action relates to supplying or liberating potassium for its own sake, or to the power of the soluble salt to increase the availability of phosphorus or other elements, is not known, but where much potassium is removed, as in the entire crops at Rothamsted, with no return of organic residues, probably the soluble salt functions in both ways.

Further evidence on this matter is furnished by the Illinois experiment field at Fairfield, where potassium sulfate has been compared with kainit both with and without the addition of organic matter in the form of stable manure. Both sulfate and kainit produced a substantial increase in the yield of corn, but the cheaper salt—kainit—was just as effective as the potassium sulfate, and returned some financial profit. Manure alone gave an increase similar to that produced by the potassium salts, but the salts added to the manure gave very little increase over that produced by the manure alone. This is explained in part perhaps because the potassium removed in the crops is mostly returned in the manure if properly cared for, and perhaps in larger part because the decaying organic matter helps to liberate and hold in solution other plant-food elements, especially phosphorus.

In laboratory experiments at the Illinois Experiment Station, it has been shown that potassium salts and most other soluble salts increase the solubility of the phosphorus in soil and in rock phosphate; also that the addition of glucose with rock phosphate in pot-culture experiments increases the availability of the phosphorus, as measured by plant growth, altho the glucose consists only of carbon, hydrogen, and oxygen, and thus contains no plant food of value.

In considering the conservation of potassium on the farm it should be remembered that in average live-stock farming the animals destroy two-thirds of the organic matter and retain one-fourth of the nitrogen and phosphorus from the food they consume, but that they retain less than one-tenth of the potassium; so that the actual loss of potassium in the products sold from the farm, either in grain farming or in live-stock farming, is negligible on land containing 25,000 pounds or more of potassium in the surface 6⅔ inches.

The Calcium and Magnesium Problem

When measured by the actual crop requirements for plant food, magnesium and calcium are more limited in some Illinois soils than potassium. But with these elements we must also consider the loss by leaching.

Doctor Edward Bartow and associates, of the Illinois State Water Survey, have shown that as an average of 90 analyses of Illinois well-waters drawn chiefly from glacial sands, gravels, or till, 3 million pounds of water (about the average

annual drainage per acre for Illinois) contained 11 pounds of potassium, 130 of magnesium, and 330 of calcium. These figures are very significant, and it may be stated that if the plowed soil is well supplied with the carbonates of magnesium and calcium, then a very considerable proportion of these amounts will be leached from that stratum. Thus the loss of calcium from the plowed soil of an acre at Rothamsted, England, where the soil contains plenty of limestone, has averaged more than 300 pounds a year as determined by analyzing the soil in 1865 and again in 1905. And practically the same amount of calcium was found by analyzing the Rothamsted drainage waters.

Common limestone, which is calcium carbonate ($CaCO_3$), contains, when pure, 40 percent of calcium, so that 800 pounds of limestone is equivalent to 320 pounds of calcium. Where 10 tons per acre of ground limestone was applied at Edgewood, Illinois, the average annual loss during the next ten years amounted to 790 pounds per acre. The definite data from careful investigations thus seem to indicate that where limestone is needed at least 2 tons per acre should be applied every four or five years.

It is of interest to note that thirty crops of clover of 4 tons each would require 3,510 pounds of calcium, while the most common prairie land of southern Illinois contains only 3,420 pounds of total calcium in the plowed soil of an acre. Thus limestone has a positive value on some soils for the plant food which it supplies, in addition to its value in correcting soil acidity and in improving the physical condition of the soil. Ordinary limestone (abundant in the southern and western parts of the state) contains nearly 800 pounds of calcium per ton; while a good grade of dolomitic limestone (the more common limestone of northern Illinois) contains about 400 pounds of calcium and 300 pounds of magnesium per ton. Both of these elements are furnished in readily available form in ground dolomitic limestone.

The Sulfur Question

In considering the relation of sulfur in a permanent system of soil fertility it is important to understand something of the cycle of transformations that this element undergoes in nature. Briefly stated this is as follows:

Sulfur exists in the soil in both organic and inorganic forms, the former being gradually converted to the latter form thru bacterial action. In this inorganic form sulfur is taken up by plants which in their physiological processes change it once more into an organic form as a constituent of protein. When these plant proteins are consumed by animals, the sulfur becomes a part of the animal protein. When these plant and animal proteins are decomposed, either thru bacterial action, or thru combustion, the sulfur passes into the atmosphere or into the soil solution in the form of sulfur dioxid gas. This gas unites with oxygen and water to form sulfuric acid, which is readily washed back into the soil by the rain, thus completing the cycle, from soil—to plants and animals—to air—to soil.

In this way sulfur becomes largely a self-renewing element of the soil, altho there is a considerable loss from the soil by leaching. Observations taken at the Illinois Agricultural Experiment Station show that 40 pounds of sulfur per acre are brought into the soil thru the annual rainfall. With a fair stock of

sulfur, such as exists in our common types of soil, and an annual return, which of itself would more than suffice for the needs of maximum crops, the maintenance of an adequate sulfur supply presents little reason at present for serious concern. There are regions, however, where the natural stock of sulfur in the soil is not nearly so high and where the amount returned thru rainfall is small. Under such circumstances sulfur soon becomes a limiting element of crop production, and it will be necessary sooner or later to introduce this substance from some outside source. Investigation is now under way to determine to what extent this situation may apply to conditions in Illinois.

Physical Improvement of Soils

In the management of most soil types, one very important thing, aside from proper fertilization, tillage, and drainage, is to keep the soil in good physical condition, or good tilth. The constituent most important for this purpose is organic matter. Organic matter in producing good tilth helps to control washing of soil on rolling land, raises the temperature of drained soil, increases the moisture-holding capacity of the soil, retards capillary rise and consequently loss of moisture by surface evaporation, and helps to overcome the tendency of some soils to run together badly.

The physical effect of organic matter is to produce a granulation or mellowness, by cementing the fine soil particles into crumbs or grains about as large as grains of sand, which produces a condition very favorable for tillage, percolation of rainfall, and the development of plant roots.

Organic matter is being destroyed during a large part of the year and the nitrates produced in its decomposition are used for plant growth. Altho this decomposition is necessary, it nevertheless reduces the amount of organic matter, and provision must therefore be made for maintaining the supply. The practical way to do this is to turn under the farm manure, straw, corn stalks, weeds, and all or part of the legumes produced on the farm. The amount of legumes needed depends upon the character of the soil. There are farms, especially grain farms, in nearly every community where all legumes could be turned under for several years to good advantage.

Manure should be spread upon the land as soon as possible after it is produced, for if it is allowed to lie in the barnyard several months as is so often the case, from one-third to two-thirds of the organic matter will be lost.

Straw and corn stalks should be turned under, and not burned. Probably no form of organic matter acts more beneficially in producing good tilth than corn stalks. It is true, they decay rather slowly, but it is also true that their durability in the soil is exactly what is needed in the production of good tilth. Furthermore, the nitrogen in a ton of corn stalks is one and one-half times that of a ton of manure, and a ton of dry corn stalks incorporated in the soil will ultimately furnish as much humus as four tons of average farm manure. When burned, however, both the humus-making material and the nitrogen are lost to the soil.

It is a common practice in the corn belt to pasture the corn stalks during the winter and often rather late in the spring after the frost is out of the ground. This tramping by stock sometimes puts the soil in bad condition for

working. It becomes partially puddled and will be cloddy as a result. If tramped too late in the spring, the natural agencies of freezing and thawing and wetting and drying, with the aid of ordinary tillage, fail to produce good tilth before the crop is planted. Whether the crop is corn or oats, it necessarily suffers, and if the season is dry, much damage may be done. If the field is put in corn, a poor stand is likely to result, and if put in oats, the soil is so compact as to be unfavorable for their growth. Sometimes the soil is worked when too wet. This also produces a partial puddling which is unfavorable to physical, chemical, and biological processes. The bad effect will be greater if cropping has reduced the organic matter below the amount necessary to maintain good tilth.

Systems of Crop Rotations

In a program of permanent soil improvement one should adopt at the outset a good rotation of crops, including a liberal use of legumes, in order to increase the organic matter of the soil either by plowing under the legume crops and other crop residues (straw and corn stalks), or by using for feed and bedding practically all the crops raised and returning the manure to the land with the least possible loss. No one can say in advance for every particular case what will prove to be the best rotation of crops, because of variation in farms and farmers and in prices for produce.

Following are a few suggested rotations, applicable to the corn belt, which may serve as models or outlines to be modified according to special circumstances.

Six-Year Rotations

First year —Corn
Second year —Corn
Third year —Wheat or oats (with clover, or clover and grass)
Fourth year —Clover, or clover and grass
Fifth year —Wheat (with clover), or grass and clover
Sixth year —Clover, or clover and grass

Of course there should be as many fields as there are years in the rotation. In grain farming, with small grain grown the third and fifth years, most of the unsalable products should be returned to the soil, and the clover may be clipped and left on the land or returned after threshing out the seed (only the clover seed being sold the fourth and sixth years); or, in live-stock farming, the field may be used three years for timothy and clover pasture and meadow if desired. The system may be reduced to a five-year rotation by cutting out either the second or the sixth year, and to a four-year system by omitting the fifth and sixth years, as indicated below.

Five-Year Rotations

First year —Corn
Second year —Wheat or oats (with clover, or clover and grass)
Third year —Clover, or clover and grass
Fourth year —Wheat (with clover), or clover and grass
Fifth year —Clover, or clover and grass

First year —Corn
Second year —Corn
Third year —Wheat or oats (with clover, or clover and grass)
Fourth year —Clover, or clover and grass
Fifth year —Wheat (with clover)

First year —Corn
Second year —Cowpeas or soybeans
Third year —Wheat (with clover)
Fourth year —Clover
Fifth year —Wheat (with clover)

The last rotation mentioned above allows legumes to be seeded four times. Alfalfa may be grown on a sixth field for five or six years in the combination rotation, alternating between two fields every five years, or rotating over all the fields if moved every six years.

Four-Year Rotations

First year —Wheat (with clover)
Second year —Corn
Third year —Oats (with clover)
Fourth year —Clover

First year —Corn
Second year —Corn
Third year —Wheat or oats (with clover)
Fourth year —Clover

First year —Corn
Second year —Wheat or oats (with clover)
Third year —Clover
Fourth year —Wheat (with clover)

First year —Wheat (with clover)
Second year —Clover
Third year —Corn
Fourth year —Oats (with clover)

First year —Corn
Second year —Cowpeas or soybeans
Third year —Wheat (with clover)
Fourth year —Clover

Alfalfa may be grown on a fifth field for four or eight years, which is to be alternated with one of the four; or the alfalfa may be moved every five years, and thus rotated over all five fields every twenty-five years.

Three-Year Rotations

First year —Corn
Second year —Oats or wheat (with clover)
Third year —Clover

First year —Wheat (with clover)
Second year —Corn
Third year —Cowpeas or soybeans

By allowing the clover, in the last rotation mentioned, to grow in the spring before preparing the land for corn, we have provided a system in which legumes grow on every acre every year. This is likewise true of the following suggested two-year system:

Two-Year Rotations

First year —Oats or wheat (with sweet clover)
Second year —Corn

Altho in this two-year rotation either oats or wheat is suggested, as a matter of fact, by dividing the land devoted to small grain, both of these crops can be grown simultaneously, thus providing a three-crop system in a two-year cycle.

It should be understood that in all of the above suggested cropping systems it may be desirable in some cases to substitute rye for the wheat or oats. In all of these proposed rotations the word *clover* is used in a general sense to designate either red clover, alsike clover, or sweet clover. The value of sweet clover especially as a green manure for building up depleted soils, as well as a pasture and hay-crop, is becoming thoroly established, and its importance in a crop-rotation program may well be emphasized.

SUPPLEMENT: EXPERIMENT FIELD DATA

(Results from Experiment Fields Representing the More Important Types of Soil Occurring in Adams County)

In the earlier reports of this series it was the practice to incorporate in the body of the report the results of certain experiment fields, for the purpose of illustrating the possibilities of improving the soil of various types. The information carried by such data must, naturally, be considered more or less tentative. As the fields grow older new facts develop, which in some instances may call for the modification of former recommendations. It has therefore seemed desirable to separate this experiment field data from the more permanent information of the soil survey, and embody the same in the form of a supplement to the soil report proper, thus providing a convenient arrangement for possible future revisions as additional data accumulate.

The University of Illinois has conducted altogether about fifty soil experiment fields in different sections of the state and on various types of soil. Altho some of these fields have been discontinued, the large majority are still in operation. It is the present purpose to report the summarized results from certain of these fields which are representative of the types of soil described in the accompanying soil report.

A few general explanations at this point, which apply to all the fields, will relieve the necessity of numerous repetitions in the following pages.

Size and Arrangement

These fields vary in size from less than two acres up to 40 acres or more. They are laid off into series of plots, the plots commonly being either one-fifth or one-tenth acre in area. Each series is occupied by one kind of crop. Usually there are several series so that a crop rotation can be carried on with every crop represented every year.

Farming Systems

On many of the fields the treatment provides for two distinct systems of farming, live-stock farming and grain farming.

In the live-stock system, stable manure is used to furnish organic matter and nitrogen. The amount applied to a plot is based upon the amount that can be produced from crops raised on that plot.

In the grain system no animal manure is used. The organic matter and nitrogen are applied in form of plant manures, including all the plant residues produced, such as corn stalks, straw from wheat, oats, clover, etc., along with leguminous catch crops plowed under. It is the plan in this latter system to remove from the land, in the main, only the grain and seed produced, except in the case of alfalfa, that crop being harvested for hay the same as in the live-stock system.

Crop Rotations

Crops which are of interest in the respective localities are grown in definite rotations, and on most of the fields provision is made so that every crop in the rotation is represented every year. The most common rotation used is wheat,

corn, oats, and clover; and often these crops are accompanied by alfalfa growing on a fifth series. In the grain system a legume catch crop, usually sweet clover, is included, which is seeded on the young wheat in the spring and plowed under in the fall or in the following spring in preparation for corn. In the event of clover failure, soybeans are substituted.

Soil Treatment

The treatment applied to the plots has, in large part, been standardized according to a rather definite system, altho many deviations from this system occur.

Following is a brief explanation of this standard system of treatment.

Animal Manures.—Animal manures, consisting of excreta from animals, with stable litter, are spread upon the respective plots in amounts proportionate to previous crop yields, the applications being made in the preparation for corn.

Plant Manures.—All crop residues produced on the land, such as stalks, straw, and chaff, are returned to the soil, and in addition a green-manure crop of sweet clover is seeded in small grains to be plowed under in preparation for corn. (On plots where limestone is lacking the sweet clover seldom survives.) This practice is designated as the *residues system.*

Mineral Manures.—The usual yearly acre-rates of application have been: for limestone, 1,000 pounds; for raw rock phosphate, 500 pounds; and for potassium, the equivalent of 200 pounds of kainit. The initial application of limestone has usually been 4 tons per acre.

Explanation of Symbols Used

0 = Untreated land or check plots
M = Manure (animal)
R = Residues (from crops, and includes legumes used as green manure)
L = Limestone
P = Phosphorus
K = Potassium (usually in the form of kainit)
N = Nitrogen (usually in the form contained in dried blood)
( ) = Parentheses enclosing figures signify tons of hay, as distinguished from bushels of seed

In discussions of this sort of data, financial profits or losses based upon assigned market values are frequently considered. However, in view of the erratic fluctuations in market values—especially in the past few years—it seems futile to attempt to set any prices for this purpose that are at all satisfactory. The yields are therefore presented with the thought that with these figures at hand the financial returns from a given practice can readily be computed upon the basis of any set of market values that the reader may choose to apply.

BROWN SILT LOAM

Several experiment fields have been conducted on brown silt loam soil at various locations in Illinois. Those located at the University have been in operation the longest and they serve well to illustrate the principles involved in the maintenance and improvement of this type of soil.

The Morrow Plots

It happens that the oldest soil experiment field in the United States is located on typical brown silt loam of the early Wisconsin glaciation, on the campus of the University of Illinois. This field was started in 1879 by George E. Morrow, who for many years was Professor of Agriculture, and these plots are known as the Morrow plots.

The Morrow series now consists of three plots divided into halves and the halves are subdivided into quarters. On one plot corn is grown continuously; on the second, corn and oats are grown in rotation; and on the third, corn, oats, and clover are rotated. The north half of each plot has had no fertilizing material applied from the beginning of the experiments, while the south half has been treated since 1904, receiving standard applications of farm manure with cover crops grown in the one-crop and two-crop systems. Phosphorus has been applied in two different forms: rock phosphate to the southwest quarter at the rate of 600 pounds, and steamed bone meal to the southeast quarter at the rate of 200 pounds per acre per year up to 1919, when the rock phosphate was increased sufficiently to bring up the total amount applied to four times the quantity of bone meal applied. At the same time the rate of subsequent application of both forms of phosphorus was reduced to one-fourth the quantity, or to 200 pounds of rock phosphate and 50 pounds of bone meal per acre per year. In 1904 ground limestone was applied at the rate of 1,700 pounds per acre to the south half of each plot, and in 1918 a further application was made at the rate of 5 tons per acre with the intention of standardizing the application to the rate of 1,000 pounds of limestone per acre per year.

Table 1 gives the yearly record of the crop yields, and Table 2 presents the same in summarized form.

FIG. 1.—CORN ON THE MORROW PLOTS IN 1910

TABLE 1.—URBANA FIELD, MORROW PLOTS: BROWN SILT LOAM; PRAIRIE; EARLY WISCONSIN GLACIATION

Crop Yields in Soil Experiments—Bushels or (tons) per acre

Years	Soil treatment applied	Corn every year	Two-year rotation		Three-year rotation		
		Corn	Corn	Oats	Corn	Oats	Clover
1879-87	None........	....	....	....	....	....	....
1888	None........	54.3	49.5	....	....	48.6	....
1889	None........	43.2	....	37.4	....	....	(4.04)
1890	None........	48.7	54.3	....	....	....	(1.51)
1891	None........	28.6	33.2	....	....	....	(1.46)
1892	None........	33.1	....	37.2	70.2	....	....
1893	None........	21.7	29.6	....	34.1	....	....
1894	None........	34.8	....	57.2	....	65.1	....
1895	None........	42.2	41.6	....	....	22.2	....
1896	None........	62.3	....	34.5	....	....	....
1897	None........	40.1	47.0	....	....	....	....
1898	None........	18.1	....	....	....	....	....
1899	None........	50.1	44.4	....	53.5	....	....
1900	None........	48.0	....	41.5	....	....	....
1901	None........	23.7	33.7	....	34.3	....	....
1902	None........	60.2	....	56.3	....	54.6	....
1903	None........	26.0	35.9	....	....	....	(1.11)
1904	None........	21.5	....	17.5	55.3	....	....
1904	MLP........	17.1	....	25.3	72.7	....	....
1905	None........	24.8	50.0	....	....	42.3	....
1905	MLP........	31.4	44.9	....	....	50.6	....
1906	None........	27.1	....	34.7	....	....	(1.42)[1]
1906	MLP........	35.8	....	52.4	....	....	(1.74)[1]
1907	None........	29.0	47.8	....	80.5	....	....
1907	MLP........	48.7	87.6	....	93.6	....	....
1908	None........	13.4	....	32.9	....	40.0	....
1908	MLP........	28.0	....	45.0	....	44.4	....
1909	None........	26.6	33.0	....	....	....	(.65)[2]
1909	MLP........	31.6	64.8	....	....	....	(1.73)[3]
1910	None........	35.9	....	33.8	58.6	....	....
1910	MLP........	54.6	....	59.4	83.3	....	....
1911	None........	21.9	28.6	....	....	20.6	....
1911	MLP........	31.5	46.3	....	....	38.0	....
1912	None........	43.2	....	55.0	....	....	16.3[1]
1912	MLP........	64.2	....	81.0	....	....	20.0[1]
1913	None........	19.4	29.2	....	33.8	....	....
1913	MLP........	32.0	25.0	....	47.8	....	....
1914	None........	31.6	....	33.6	....	39.6	....
1914	MLP........	39.4	....	58.2	....	60.4	....
1915	None........	40.0	49.0	....	....	....	24.2[1]
1915	MLP........	66.0	81.2	....	....	....	27.1[1]
1916	None........	11.2	....	37.5	27.8	....	....
1916	MLP........	10.8	....	64.7	40.6	....	....
1917	None........	40.0	48.4	....	....	68.4	....
1917	MLP........	78.0	81.4	....	....	86.9	....
1918	None........	13.6	....	27.2	....	....	(2.58)
1918	MLP........	32.6	....	59.3	....	....	(4.04)
1919	None........	24.0	30.8	....	52.2	....	....
1919	MLP........	43.4	66.2	....	70.8	....	....
1920	None........	28.2	....	37.2	....	52.2	....
1920	MLP........	54.4	....	51.6	....	69.7	....
1921	None........	19.8	30.6	....	....	....	(.26)[4]
1921	MLP........	42.2	63.4	...	....	....	(1.33)[5]

[1]Soybeans.
[2]In addition to the hay, .64 bushel of seed was harvested.
[3]In addition to the hay, 1.17 bushels of seed were harvested.
[4]In addition to the hay, .53 bushel of seed was harvested.
[5]In addition to the hay, .85 bushel of seed was harvested.

TABLE 2.—URBANA FIELD, MORROW PLOTS: GENERAL SUMMARY
Average Annual Yields—Bushels or (tons) per acre

Years	Soil treatment applied	Corn every year	Two-year rotation		Three-year rotation		
			Corn	Oats	Corn	Oats	Clover
		16 crops	*9 crops*	*6 crops*	*4 crops*	*4 crops*	*4 crops*
1888 to 1903	None........	39.7	41.0	44.0	48.0	47.6	(2.03)
		18 crops	*9 crops*	*9 crops*	*6 crops*	*6 crops*	*4 crops*
1904	None........	26.2	38.6	34.4	51.4	43.9	(1.23)[1]
to 1921	MLP........	41.2	62.9	55.2	68.1	58.3	(2.21)[1]

[1]One crop of soybean hay.

Summarizing the data from these Morrow plots into two periods with the second period beginning in 1904 when the treatment began on the half-plots, some interesting comparisons may be made. In the first place we find in the continuous corn plot a marked decrease in the second period in the average yield of corn, amounting to one-third of the crop. In the two-year rotation there is a decrease in both corn and oats production, while the averages for the three-year system show an increase in corn yield and decreases in oats and clover. Unfortunately the numbers of crops included in these last averages are too small to warrant positive conclusions.

The increase brought about by soil treatment stands out in all cases, showing the possibility not only of restoring but also of greatly improving the productive power of this land that has been so abused by continuous cropping without fertilization.

The Davenport Plots

Another set of plots on the University campus at Urbana, forming a more extensive series than the Morrow plots, but of more recent origin, are the Davenport plots. Here each crop in the rotation is represented every year. These plots were laid out in 1895, but special soil treatment was not begun until 1901. They now comprize five series of ten plots each, and each series constitutes a "field" in a crop rotation system.

From 1901 to 1911 three of the series were in a three-year rotation system of corn, oats, and clover, while the remaining two series rotated in corn and oats. In 1911 these two systems were combined into a five-series field, with a crop rotation of wheat, corn, oats, and clover, with alfalfa on a fifth field. The alfalfa occupies one series during a rotation of the other four crops, shifting to another series in the fifth year, thus completing the cycle of all series in twenty-five years.

The soil treatment applied to these plots has been as follows:

Legume cover crops were seeded in the corn at the last cultivation on Plots 2, 4, 6, and 8, from 1902 to 1907, but the growth was small and the effect, if any, was to decrease the returns from the regular crops. Crop residues (R) have been returned to these same plots since 1907. These consist of stalks and straw, and all legumes except alfalfa hay and the seed of clover and soybeans. Beginning in 1918 a modification of the practice was made in that one cutting of the red clover crop is harvested as hay. In conjunction with these residues a catch crop of sweet clover grown with the wheat is plowed under.

Manure (M) was applied preceding corn, at the rate of 2 tons per acre per year in 1905, 1906, and 1907; subsequently as many tons have been applied as there have been tons of air-dry produce harvested from the respective plots.

Lime (L) was applied on Plots 4 to 10 at the rate per acre of 250 pounds of air-slaked lime in 1902, and 600 pounds of limestone in 1903. No further application was made until 1911, when the system of cropping was changed. Since that time applications of limestone have been made at the rate of one-half ton per acre per year.

Phosphorus (P) was applied on Plots 6 to 9 at the rate of 25 pounds per acre per annum in 200 pounds of steamed bone meal; but beginning with 1908 rock phosphate at the rate of 600 pounds per acre per annum was substituted for the bone meal on the west half of each of these plots. These applications continued until 1918 when adjustments were begun, first to make the rate of application of rock phosphate four times that of the bone meal, and finally to reduce the amounts of these materials to 200 pounds of rock phosphate and 50 pounds of bone meal per acre per annum. The usual practice has been to apply and plow under at one time all phosphorus and potassium required for the rotation.

Potassium (K = kalium) has been applied on Plots 8 and 9, in connection with the organic manures and phosphorus, at the yearly rate of 42 pounds per acre, and mainly as potassium sulfate.

On Plot 10 about five times as much manure and phosphorus are applied as on the other plots, but this "extra heavy" treatment was not begun until 1906, only the usual amounts of lime, phosphorus, and potassium having been applied in previous years. The purpose in making these heavy applications is to try to determine the climatic possibilities in crop yields by removing the limitations of inadequate fertility.

It will be observed that the applications mentioned above provide for the two rather distinct systems of farming already described. *The grain system,* in which animal manure is not produced and where the organic matter is provided by the direct return to the soil of all crop residues along with legumes, is exemplified in Plots 2, 4, 6, and 8; and the *live-stock system,* in which farm manure is utilized for soil enrichment, is represented in Plots 3, 5, 7, and 9.

Table 3 shows a summary of the results obtained on the Davenport plots beginning with the year 1911, when the present cropping system was introduced.

When used in conjunction with phosphorus the crop residues and the manure appear about equally effective; but where phosphorus is not applied, the manure has been decidedly more effective, under the conditions of the experiment. It should be observed, however, in this connection, that the plowing under of clover is a very essential feature of the residues system, and that, as a matter of fact, there were five clover failures, when soybeans were substituted, during the ten years. Perhaps with a more reliable biennial legume than red clover, the results would have been more favorable for this system.

By comparing Plots 2 and 3 with Plots 4 and 5, it is found that limestone has had a beneficial effect on all crops. What the financial profit amounts to depends obviously upon the market value of the crops and the cost of the limestone.

TABLE 3.—URBANA FIELD, DAVENPORT PLOTS: BROWN SILT LOAM, PRAIRIE; EARLY WISCONSIN GLACIATION

Average Annual Yields—Bushels or (tons) per acre

1911–1920

Serial plot No.	Soil treatment applied	Corn	Oats	Wheat	Clover 5 crops	Soybeans 5 crops	Alfalfa
1	0	55 6	50.5	26.0	(2 42)	(1 47)	(2.43)
2	R	57.1	52.3	28.7	1 47[1]	19 8	(2.46)
3	M	66.3	61.9	[illegible]	(2.56)	(1.62)	(2 52)
4	RL	64.8	55.6	31.4	1.61[1]	20 3	(2.72)
5	ML	69.6	64.1	32 8	(2.90)	(1.67)	(3 03)
6	RLP	71 5	69 8	43.0	2 29[1]	[illegible]	(3.69)
7	MLP	73.0	68 6	40.0	(3.52)	(1.97)	(3.76)
8	RLPK	70 9	72 5	40.7	1.79[1]	25 5	(3 77)
9	MLPK	70.2	72 0	39 2	(3 40)	(2.20)	(3.73)
10	Mx5LPx5	65 9	71.4	40.6	(3.31)	(2 22)	(3 77)

[1]In addition to the clover seed, a crop of hay was harvested one year on Plots 2, 4, 6, and 8, yielding 2.38, 2.20, 2.54, and 2.39 tons respectively.

Comparing Plots 4 and 5 with Plots 6 and 7, respectively, there is found in all cases an increase in crop yield as a result of adding phosphorus. The effect on wheat is especially pronounced. Where limestone and phosphorus are applied in addition to the crop residues, an increase of 17 bushels of wheat, over the yield of the untreated land, has been obtained as a ten-year average.

Manure
Yield: 1.43 tons per acre

Manure, limestone, phosphorus
Yield: 2.90 tons per acre

FIG. 2.—CLOVER ON THE DAVENPORT PLOTS IN 1913

The effect of adding potassium to the treatment is of much interest. Plots 8 and 9 are the same as Plots 6 and 7, respectively, except that potassium has been applied to the former. On the whole, no significant benefit is shown from the addition of potassium.

No benefit appears as the result of the extra-heavy applications of manure and phosphorus on Plot 10. In fact the corn yields are noticeably less here than on the plots receiving the normal applications of these materials.

The University South Farm

On the University South Farm, at Urbana, several series of plots devoted primarily to variety testing and other crop-production experiments are so laid out as to show the effects of certain soil treatments that have been applied. Several different systems of crop rotation are employed and the crops are so handled as to exemplify the two general systems of farming, grain and live-stock.

The summarized results presented in Table 4 represent three different systems of cropping. The first, designated as the Southwest rotation, is to be regarded as a good rotation for general practice, on this type of soil, under Illinois conditions. This is a four-field rotation of wheat, corn, oats, and clover.

TABLE 4.—URBANA FIELD, SOUTH FARM: BROWN SILT LOAM, PRAIRIE; EARLY WISCONSIN GLACIATION

Average Annual Yields—Bushels or (tons) per acre
1908-1919

Southwest Rotation: Series 100, 200, 400[1]: Wheat, Corn, Oats, Clover[2]

Soil treatment applied[6]	Corn 9 crops	Oats[3] 9 crops	Wheat[3] 8 crops	Clover[4] 3 crops	Soybeans 7 crops
RP	62.3	51.9	41.0	1.05	17.3[5]
R	51.9	46.5	26.9	1.38	16.2[5]
M	59.7	50.2	29.1	(2.28)	(1.25)
MP	64.3	55.4	43.1	(2.86)	(1.51)
RLP	60.5	57.2	41.8	.64	16.4[5]
R	49.7	49.6	25.8	.83	14.7[5]
M	55.5	54.1	27.8	(1.71)	(1.28)
MLP	64.1	59.6	43.9	(1.77)	(1.58)

North-Central Rotation: Series 500, 600, 700[1]: Corn, Corn, Oats, Clover[2]

Soil treatment applied[6]	Corn 1st year 9 crops	Corn 2d year 9 crops	Oats 9 crops	Clover 5 crops	Soybeans 4 crops
RP	56.7	51.1	56.1	.54	16.9
R	51.7	45.2	52.0	.50	16.0
M	54.9	46.7	52.1	(2.29)	(1.60)
MP	56.5	53.4	56.9	(2.73)	(1.74)

South-Central Rotation: Series 500, 600, 700[1]: Corn Corn, Corn, Soybeans

Soil treatment applied[6]	Corn 1st year 9 crops	Corn 2d year 9 crops	Corn 3d year 9 crops		Soybeans 9 crops
RP	51.9	44.0	41.3		20.0
R	45.5	39.9	35.2		19.2
M	50.1	42.1	33.5		(1.59)
MP	54.5	46.7	42.0		(1.66)

[1]Results from Series 300 and 800 are omitted on account of variation in soil type.
[2]Soybeans when clover fails.
[3]Only seven crops with limestone.
[4]Only one crop with limestone.
[5]Average of five crops.
[6]All phosphorus plots received ½ ton per acre of limestone in 1903.

TABLE 5.—COMPARING PRODUCTION OF CORN IN THREE DIFFERENT ROTATION SYSTEMS
YIELDS FROM PLOTS ON THE UNIVERSITY SOUTH FARM

Twelve-Year Average (1908–1919)—Bushels per acre

Rotation	Wheat-corn-oats-legume[1]	Corn-corn-oats-legume[2]		Corn-corn-corn-legume[3]		
Treatment	Corn	1st Corn	2d Corn	1st Corn	2d Corn	3d Corn
Organic manures............	[illegible]	53.3	46 0	47 8	41.0	34.3
Organic manures, phosphorus...	63.2	56 6	52 3	53.2	45.3	41.6

[1]Clover 3 crops and soybeans 7 crops.
[2]Clover 5 crops, and soybeans 5 crops.
[3]Soybeans 9 crops.

The second, or North-Central rotation, consisting of corn, corn, oats, and clover, represents a system very commonly practiced; and the third or South-Central rotation, consisting of corn, corn, corn, and soybeans, must be considered as a poor rotation from the standpoint of maintaining the productiveness of the land.

On the whole, the "residues" have not returned yields quite so high as those produced by the manure treatment; but, as remarked above in the discussion of the Davenport plots, the residues system has probably been at a disadvantage thru frequent clover failures. On the North-Central rotation, where conditions seem to have been more favorable for clover, there is very little difference between the effect of manure and of residues.

Residues plowed under
Yield: 35.2 bushels per acre

Residues and rock phosphate
Yield: 50.1 bushels per acre

FIG. 3.—WHEAT ON THE UNIVERSITY SOUTH FARM IN 1911

In the rotation system in which limestone is being applied, no benefit of consequence to any of the crops except oats appears from the use of this material. The test, however, has hardly been of sufficient duration to warrant final conclusions; and furthermore, the comparison may be somewhat impaired by a possible residual effect of the small application of limestone made in 1903 to all the phosphorus plots.

The results obtained from the use of phosphorus are important because this element has been applied to these plots solely in the form of raw rock phosphate. The figures in almost every case show an increase in yield where the phosphorus has been applied, and in most cases this increase is very pronounced. The wheat is especially responsive to phosphorus.

The records furnish some interesting comparisons of corn yields produced under different systems of cropping. Table 5 gives a general summary of the corn yields only, in which the results from the residues and manure treatments are averaged together as "organic manures." The highest annual acre-yields are found where corn occurs but once in a rotation. Where corn is grown twice in succession, the annual acre-yields are less; and where corn occurs three times, there is a further reduction. Also, the first crop of corn within a rotation produces more than the second, and the second crop yields more than the third. These are useful facts for consideration in connection with problems of general farm management.

The Clayton Field

An experiment field representing a light phase of the brown silt loam is located in Adams county just south of Clayton. This field has been in operation since 1911. The diagram presented as Fig. 4 shows the arrangement of the plots on this field.

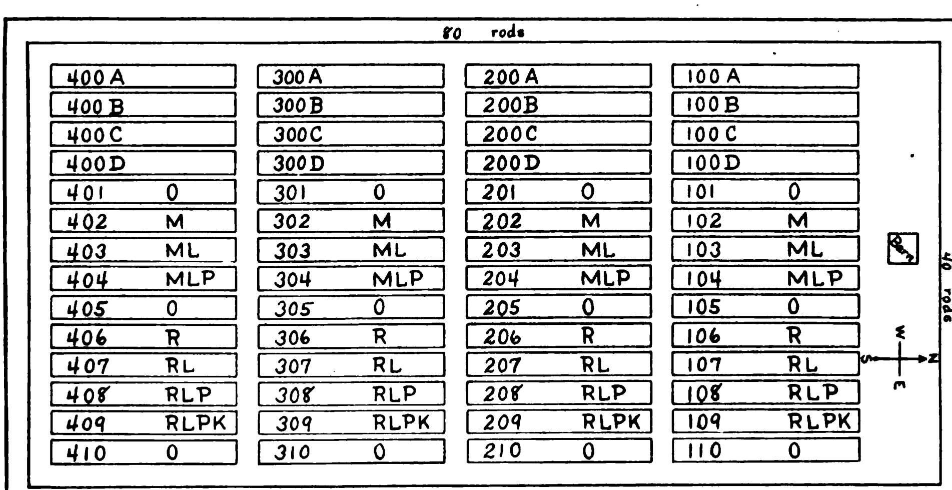


FIG. 4.—DIAGRAM SHOWING ARRANGEMENT OF PLOTS ON THE CLAYTON EXPERIMENT FIELD

TABLE 6.—CLAYTON FIELD: BROWN SILT LOAM, PRAIRIE; UPPER ILLINOISAN GLACIATION
ROTATION: WHEAT, CORN, OATS, CLOVER

Crop Yields—Bushels or (tons) per acre

Plot No.	Soil treatment applied	1911 Corn[1]	1912 Oats[2]	1913 Soybeans[5]	1914 Wheat[6]	1915 Corn	1916 Oats	1917 Clover	1918 Wheat	1919 Corn	1920 Oats	1921 Soybeans
101	0.......	45.8	43.0	10.3	5.0	23.3	19.2	(2.01)	27.3	37.7	22.3	20.1
102	M......	50.0	42.3	(1.49)	4.8	27.3	21.6	(2.51)	30.2	50.3	38.1	18.8
103	ML.....	52.4	39.3	(1.58)	5.3	28.6	20.8	(3.26)	42.8	47.9	32.8	28.1
104	MLP....	48.7	46.9	(1.50)	5.4	31.5	23.0	(3.55)	47.0	41.6	40.6	21.5
105	0.......	54.6	44.1	12.1	6.2	25.6	20.3	1.92	33.3	30.1	25.9	21.3
106	R.......	56.5	40.0	12.5	8.5	36.0	20.2	2.17	33.7	49.7	43.1	25.8
107	RL......	57.6	41.6	13.5	6.8	55.4	31.4	2.17	45.5	57.9	52.8	24.3
108	RLP....	55.5	42.3	13.0	8.8	55.2	38.6	2.00	50.8	59.0	55.5	20.3
109	RLPK...	52.0	43.8	11.8	7.9	56.5	35.9	2.00	47.6	70.7	51.9	25.5
110	0.......	54.0	50.0	12.7	7.5	27.3	25.9	(2.94)	31.2	49.3	46.1	17.5
		Oats[1]	Corn[3]	Oats	Soybeans	Wheat	Corn	Oats	Clover	Wheat	Corn	Oats
201	0.......	19.5	35.4	45.5	(1.28)	11.2	17.1	63.8	(2.74)	21.7	44.3	28.4
202	M......	19.1	47.4	55.3	(1.41)	17.9	21.4	71.6	(2.79)	18.9	66.4	45.2
203	ML.....	16.9	36.9	51.6	(1.38)	14.5	21.5	70.6	(2.78)	19.0	75.1	42.2
204	MLP....	20.9	56.8	56.1	(1.45)	23.2	21.0	72.3	(2.61)	18.6	76.7	39.2
205	0.......	18.9	38.7	45.9	14.2	7.0	15.2	65.9	(2.06) 1.00	20.3	53.2	31.2
206	R.......	18.1	52.1	45.9	16.7	16.2	26.7	69.8	(2.18) .83	19.8	59.2	32.0
207	RL......	18.9	50.5	48.3	18.3	16.1	26.8	82.8	(2.18) .58	19.3	65.7	34.2
208	RLP....	20.9	54.4	52.2	19.6	30.2	26.9	77.5	(2.54) .58	20.0	70.1	39.8
209	RLPK...	17.5	55.5	47.7	17.1	29.2	24.6	83.6	(2.29) .42	21.2	71.6	41.9
210	0.......	25.0	36.2	45.5	(1.40)[7]	14.8	15.1	65.9	(2.60)	20.3	46.1	30.6

TABLE 6.—CLAYTON FIELD, *Concluded*

		1911 Soy-beans[1]	1912 Barley[4]	1913 Corn	1914 Oats	1915 Soy-beans	1916 Wheat	1917 Corn	1918 Oats	1919 Soy-beans	1920 Wheat	1921 Corn
301	0.......	12.0	19.6	35.4	10.0	(2.52)	1.6	30.4	38.6	(1.55)	16.4	30.1
302	M......	12.5	19.7	55.2	14.7	(2.58)	2.0	52.8	49.2	(1.66)	30.8	52.3
303	ML.....	13.0	20.2	55.1	13.3	(2.83)	3.9	61.2	50.6	(1.86)	27.5	67.9
304	MLP....	12.8	22.6	58.4	15.9	(3.11)	4.6	60.5	53.9	(1.62)	32.8	67.7
305	0.......	14.6	21.5	42.1	13.9	12.5	1.8	35.2	37.5	23.1	11.0	42.3
306	R.......	14.4	21.4	49.7	17.3	12.5	4.4	52.6	46.9	20.8	11.5	58.4
307	RL......	14.8	22.2	52.2	16.6	19.2	5.6	59.9	57.0	23.5	19.6	65.0
308	RLP....	14.8	24.5	55.1	18.4	19.6	7.5	65.6	73.4	25.0	21.9	66.0
309	RLPK...	14.8	30.8	52.6	16.9	22.5	9.0	64.0	69.7	27.5	22.7	73.3
310	0.......	13.8	18.9	43.6	14.7	(2.21)	1.7	20.3	35.3	(1.38)	19.2	43.9
		Oats[1]	Soy-beans[2]	Wheat[6]	Corn	Oats	Clover	Wheat	Corn	Oats	Clover	Wheat
401	0.......	27.0	16.4	32.9	36.0	58.1	(2.30)	18.0	20.2	42.5	(1.70)	21.4
402	M......	32.2	(1.36)	31.0	37.8	61.6	(2.77)	21.7	49.8	50.3	(2.44)	29.1
403	ML.....	30.0	(1.36)	31.6	48.7	64.5	(2.76)	21.6	57.1	51.4	(2.64)	32.0
404	MLP....	30.8	(1.36)	34.0	46.1	69.5	(2.51)	23.5	50.4	49.5	(2.53)	32.1
405	0.......	32.8	17.5	34.1	29.9	60.5	1.83	20.4	22.1	45.0	(1.40) .96	22.6
406	R.......	33.3	16.7	33.3	30.4	50.5	1.58	26.7	33.7	46.7	(1.64) .83	24.1
407	RL......	33.3	16.9	33.8	41.6	62.5	1.00	21.5	44.6	43.0	(2.92) .80	29.1
408	RLP....	39.3	17.2	37.0	31.9	68.0	1.00	23.2	42.5	48.0	(2.55) 1.71	31.4
409	RLPK...	34.7	16.3	37.3	45.5	65.6	1.25	24.7	51.5	51.9	(3.10) .96	30.2
410	0.......	35.6	17.5	35.0	34.8	62.2	(2.15)	16.0	24.4	47.8	(1.98)	22.3

[1]No treatment. [2]Residues only. [3]No lime. [4]No manure or lime. [5]No manure, phosphate or potassium. [6]No manure. [7]Estimated.

There are four series of plots, the series numbering by hundreds from north to south. Each series has fourteen plots numbering in order from west to east and separated by half-rod division strips. Plots A, B, C, and D have only recently been added to the regular series, and no results are reported for these plots at this time.

The crop rotation practiced on this field is wheat, corn, oats, and clover. Soybeans have several times been substituted for the clover. The yields of all the crops grown each year since the beginning of the experiments are presented in Table 6. These results are summarized in Table 7, which shows the average yields of the respective crops for each treatment covering the years that full treatment has been under way. The lower section of this table gives a more condensed summary which affords some interesting comparisons. Here the results from the corresponding plots of the live-stock and grain systems are so combined as to bring out the effect of organic manures alone, organic manures in combination with limestone, and organic manures in combination with limestone and phosphorus.

TABLE 7.—CLAYTON FIELD: GENERAL SUMMARY
Average Annual Yields—Bushels or (tons) per acre 1913-1921

Serial plot No.	Soil treatment applied	Wheat 7 crops	Corn 9 crops	Oats 9 crops	Legumes[1] 8 crops
1	0	16.8	30.5	36.5	(2.01)
2	M	21.5	45.9	45.3	(2.26)
3	ML	23.0	51.5	44.2	(2.54)
4	MLP	26.0	50.4	46.7	(2.44)
5	0	16.6	33.0	38.5	(2.04)
6	R	19.5	44.0	41.4	(2.10)
7	RL	22.4	52.1	47.6	(2.27)
8	RLP	26.4	52.5	52.4	(2.35)
9	RLPK	26.4	56.7	51.7	(2.41)
10	0	17.9	33.9	41.6	(2.05)
4, 8	M, R } LP	26.2	51.5	49.6	(2.40)
3, 7	M, R } L	22.7	51.8	45.9	(2.41)
2, 6	M, R }	20.5	45.0	43.4	(2.18)
1, 5, 10	0	17.1	32.5	38.9	(2.03)

[1]These figures represent the average combined yields of clover and soybeans, whether hay or seed, expressed as the equivalent of clover hay.

In looking over these results, attention is called first to the beneficial effect of organic manures, whether they have been applied in the form of animal manure or as plant manures (crop residues and legumes turned under). This improvement obtained by adding organic matter indicates the importance of carefully conserving and regularly applying all available farm manure. If farm manure is not available in sufficient quantity, then, as these results demonstrate, the necessary organic matter can be supplied by returning to the land all unused crop residues and by plowing under legume crops.

The results also bring out the beneficial effect of limestone on this soil, all crops showing in the general averages increases in yield where this material has been applied.

The use of raw rock phosphate applied along with organic manures and limestone has produced still further increases for wheat and oats, but not for corn. Potassium salts appear to have benefited the corn, but not the wheat and oats, altho the increase in corn yield would not pay for the cost of the treatment.

On the whole, the results of the Clayton field are in accord with what has been found to be generally true of the brown silt loam type of soil. For the establishment of a permanent system of fertility, organic matter and phosphorus are needed, and where limestone is lacking this material should be applied. Where organic manures, limestone, and phosphate have been applied on the Clayton field, the yield of wheat has averaged 26.2 bushels per acre as compared with 17.1 bushels on the check plots, an increase amounting to ½ of the crop that was produced without treatment; the yield of corn has averaged 51.5 bushels as compared with 32.5 bushels, also an increase of more than 50 percent; the yield of oats has averaged 49.6 bushels as compared with 38.9 bushels, representing about a 25 percent increase; the yield of hay, or its equivalent (the value of seed crops produced being expressed as the equivalent to tons of hay), has averaged 2.40 tons per acre as compared with 2.03 tons, an increase of about ⅙ of the untreated crop.

YELLOW-GRAY SILT LOAM

Yellow-gray silt loam exhibits an important variation with respect to limestone content. In some areas, altho limestone may be altogether absent in the surface stratum it is found in abundance at a short distance beneath the surface. Accordingly, variations in response to soil treatment are exhibited by different experiment fields located on this type. In view of this discrepancy it is thought well to introduce here the records of two fields, that are representative of the type but which show a marked diversity in results, one in northern Illinois and one in the southern part of the state.

The Antioch field is located on the late Wisconsin glaciation, in Lake county, close to the Wisconsin border. The field was started in 1902, with but a single series of ten plots, under a rotation of corn, corn, oats, and wheat; but beginning with 1911 the rotation has been wheat, corn, oats, and clover. It was started in order to learn as quickly as possible what effect would be produced by the addition to this type of soil of nitrogen, phosphorus, and potassium, used singly and in combination. Therefore these elements were all applied in commercial form until 1911, after which the use of commercial nitrogen was discontinued and crop residues were substituted in its place. Nitrogen was supplied in the earlier years in 800 pounds of dried blood per acre. Phosphorus is applied in 200 pounds of steamed bone meal, and potassium in 100 pounds of potassium sulfate. At the beginning, 470 pounds of slaked lime was applied; but since 1912 limestone has been applied at the rate of 1,000 pounds per acre per year.

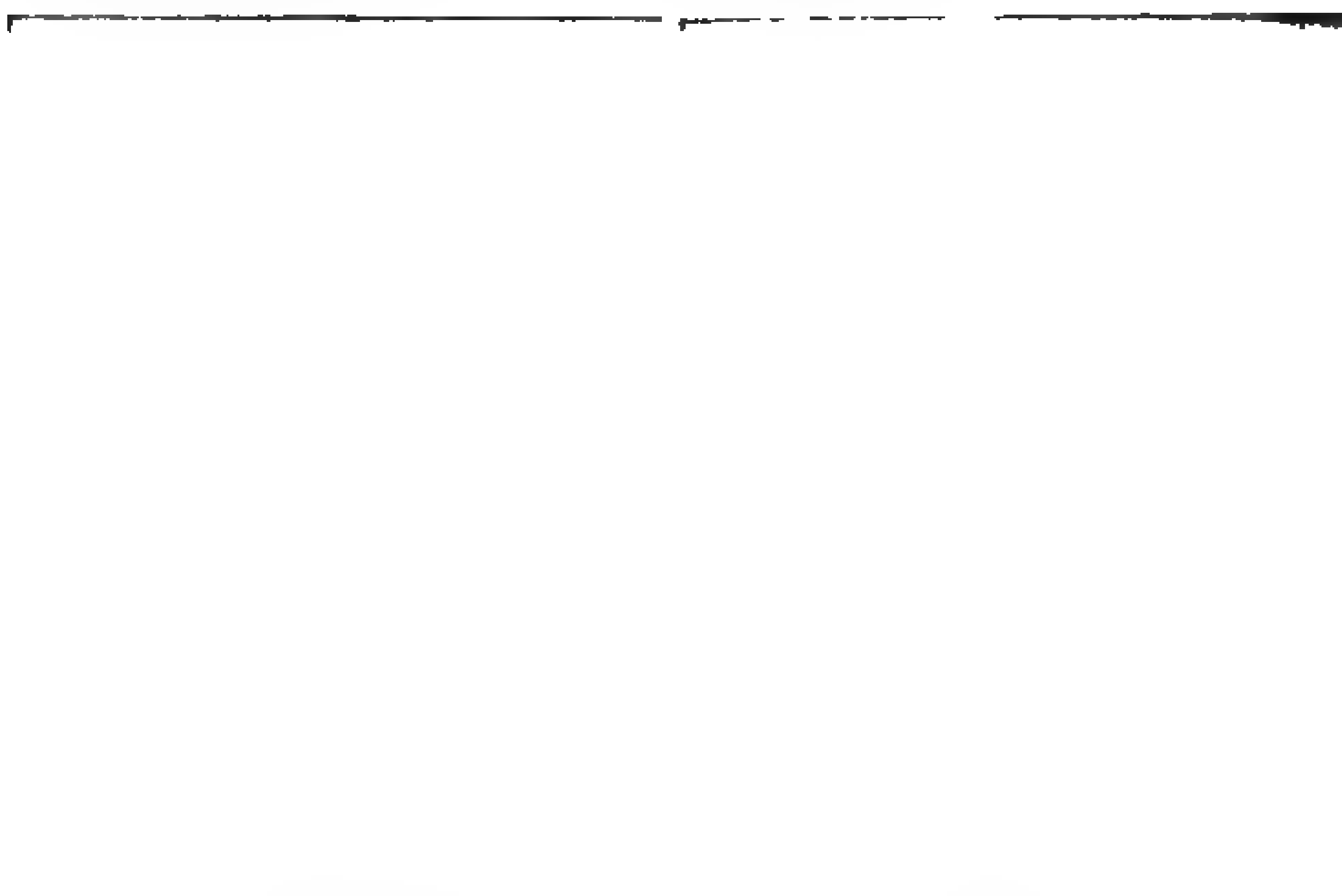
Table 8 presents, in summarized form, the results from the Antioch field. Because of an abnormality in Plot 1, the results from this plot are not considered. The data show that phosphorus is the one element standing out prominently as producing consistently beneficial results. Potassium applied in addition to phosphorus has, on the whole, not produced profitable results. Also, the

TABLE 8.—ANTIOCH FIELD: YELLOW-GRAY SILT LOAM, TIMBER SOIL; LATE WISCONSIN GLACIATION

Average Annual Yields—Bushels or (tons) per acre
1902-1921

Serial plot No.	Soil treatment applied	Corn 8 crops	Oats 5 crops	Wheat 4 crops	Clover[1] 3 crops
1	0	23.9	32 3	15 8	1 33
2	L	21.3	26 8	13.2	1 26
3	LR	21.3	29.9	[illegible]	1.45
4	LP	30.7	43.6	36.7	1.61
5	LK	23 7	27.8	19 2	1.21
6	LRP	33 8	43.3	33.3	1.13
7	LRK	24.3	26.9	20.8	1.22
8	LPK	25 1	38 2	30 9	1.51
9	LRPK	38 3	42.6	28 0	1.00
10	RPK	38 4	44 7	30 2	1.28

[1] These figures represent the average combined yields of hay and seed, expressed as the equivalent of clover hay.



Lime applied and residues plowed under — Lime and phosphorus applied

FIG. 5.—CLOVER IN 1913 ON ANTIOCH FIELD

results are unfavorable for the application of limestone. Limestone, however, is abundant in the subsoil of this type in the region of this field.

The Raleigh experiment field is located on the lower Illinoisan glaciation, in southern Illinois, in Saline county. This field is laid out into four series of ten plots each, under a rotation of wheat, corn, oats, and clover. The treatments, along with the summarized results, are given in Table 9.

The outstanding feature of these results is the effect of limestone. Altho manure alone produces a substantial increase, especially in the corn crop, when

Manure, limestone, phosphorous
Yield: 61 bushels per acre

Nothing applied
Yield: 15 bushels per acre

FIG. 6.—CORN ON RALEIGH FIELD IN 1920

TABLE 9.—RALEIGH FIELD: YELLOW-GRAY SILT LOAM, TIMBER SOIL; LOWER ILLINOISAN GLACIATION

Average Annual Yields—Bushels or (tons) per acre
1911-1921

Serial plot No.	Soil treatment applied	Corn 11 crops	Oats 11 crops	Wheat 7 crops	Legumes[1] 9 crops
1	0....................	15.8	10.2	6.2	(.42)
2	M....................	27 6	12.5	7.9	(.55)
3	ML..................	39 0	19.6	21.7	(1.14)
4	MLP................	40 0	19.8	22 5	(1 36)
5	0....................	16.4	10.0	7.3	(.14)
6	R....................	19.4	12.8	8.8	(.19)
7	RL..................	34.3	21.2	19.7	(.71)
8	RLP................	36.7	22 4	22.4	(81)
9	RLPK.........	42.7	23.0	23 8	(.81)
10	0.........	20 2	11 2	6 9	(.30)

[1] These figures represent the average combined yields of clover and soybeans, whether hay or seed, expressed as the equivalnt of clover hay.

limestone is added a remarkable increase is found in all crops. A most important fact is that the organic matter can be effectively built up thru the use of crop residues, with the application of limestone, so that the crop yields are practically as high under this "grain system" of farming as where manure is used.

Phosphorus thus far has given only moderate returns in increased crop yields, but with an increasing quantity of organic matter and nitrogen it is probable that the phosphorus applications will show up more favorably on subsequent crops. As to the use of potassium, it is to be noted that aside from an

increase of 6 bushels of corn in the residues system, the beneficial effect has not been sufficient to justify the use of this material.

In accounting for the discrepancy in the response to limestone on these two fields, the fact is to be considered that the Antioch field is located on the late Wisconsin glaciation, where the subsoil contains large quantities of limestone; while the Raleigh field represents the lower Illinoisan glaciation, the soil of which is very acid to a great depth.

In view of these variations, a general recommendation for a complete treatment for soil of this type, that will apply to all localities, cannot be given out until more information is acquired.

Fortunately, however, each farmer can determine for himself the need of limestone for his land by applying the simple tests for the presence of carbonates and soil acidity, as explained under the discussion of limestone on pages 36 and 37 of the Appendix.

Phosphorus, which has paid well on the Antioch field, and has given doubtful returns thus far at Raleigh, has varied considerably in its effect when used on other fields located on this same type of soil. In this situation, therefore, the present suggestion would be that each farmer might well try out phosphorus on his own land, on a limited scale, and be guided by the outcome of his experience. The low phosphorus content of the surface stratum of this soil is an indication that in a system of permanent agriculture the time is not far off when phosphorus will become a limiting element to crop production, and the wise farmer will watch carefully the indications and be ready to make timely provision for this need.

YELLOW SILT LOAM

Because such a large proportion of the area of Adams county is made up of yellow silt loam it is thought that an account of some experiments on the Vienna field, the single representative of this type of soil, would be of interest here.

The Vienna Field

In 1906 the University acquired a sixteen-acre tract of land representative of yellow silt loam near Vienna in Johnson county. The whole area with the exception of about three acres had been abandoned because so much of the surface soil had washed away and there were so many gullies as to render further cultivation of this land unprofitable. Experiments were started at once to reclaim this land, the different methods described below being used for this purpose.

The field was divided into five sections. The sections designated as A, B, and C were divided into four plots each, and D into three plots. On section A, which included the steepest part of the area and contained many gullies, the land was built up into terraces at vertical intervals of five feet. Near the edge of each terrace a small ditch was placed so that the water could be carried to a natural outlet without doing much washing.

On section B the so-called embankment method was used. By this method erosion is prevented by plowing up ridges sufficiently high so that on the occasion of a heavy rainfall if the water breaks over it will run over in a broad

FIG. 7.—CORN CROP ON THE VIENNA EXPERIMENT FIELD GROWING ON IMPROVED HILLSIDE LAND THAT HAD BEEN FORMERLY BADLY ERODED. COMPARE WITH FIG. 8

sheet rather than in narrow channels. At the steepest part of the slope, hillside ditches were made for carrying away the run-off.

Section C was washed badly but contained only small gullies. Here the attempt was made to prevent washing by incorporating organic matter in the soil and practicing deep contour plowing and contour planting. With two exceptions, each year about eight loads of manure per acre were turned under for the corn crop.

The land on section D was washed to about the same extent as that of section C. As a check on the different methods of reducing erosion, the land on section D was farmed in the most convenient way, without any special effort being made to prevent washing.

FIG. 8.—VIEW OF UNIMPROVED HILLSIDE LAND TAKEN JUST OVER THE FENCE FROM THE FIELD SHOWN IN FIG. 7

Section E was badly eroded and gullied and no attempt was made to crop it other than to fill in the gullies with brush and to seed the land to grass.

Sections A, B, C, and D were not entirely uniform; some parts were washed more than others and portions of the lower-lying land had been affected by soil material washed down from above. When the field was secured, the higher land had a very low producing capacity. On many spots little or nothing would grow.

Limestone was applied to the entire field at the rate of 2 tons per acre. Corn, cowpeas, wheat, and clover were grown in a four-year rotation on each section except D which had but three plots.

Table 10 contains a summarized statement of the results obtained.

TABLE 10.—VIENNA FIELD: METHODS OF HANDLING HILLSIDE LAND TO PREVENT EROSION
Average Annual Yields—Bushels or (tons) per acre
1907-1915

Section	Method	Corn 7 crops	Wheat 7 crops	Clover 3 crops
A	Terrace	31.4	9.0	(0.68)
B	Embankments and hillside ditches	32.4	12.7	(0.97)
C	Organic matter, deep contour plowing, and contour planting	27.9	11.7	(0.80)
D	Check	14.1	4.6	(0.21)

These results indicate something of the possibilities in improving hillside land by protecting it from erosion. The average yield of corn from the protected series (A, B, and C) was 30.6 bushels per acre, as against 14.1 bushels for series D; wheat yielded 11.1 bushels in comparison with 4.6 bushels; and clover .82 ton in comparison with .21 ton.

A comparison of Figs. 7 and 8 will serve to indicate the possibility of improving this type of soil.

UNIVERSITY OF ILLINOIS

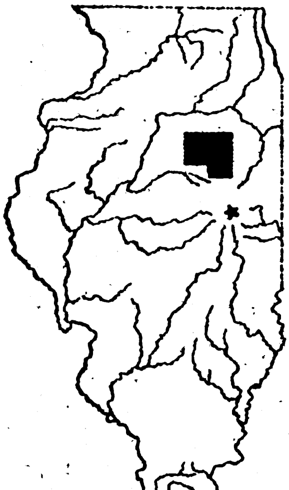
Agricultural Experiment Station

SOIL REPORT No. 25

LIVINGSTON COUNTY SOILS

By J. G. MOSIER, S. V. HOLT, F. A. FISHER, E. E. DE TURK, AND H. J. SNIDER

PREPARED FOR PUBLICATION BY L. H. SMITH



URBANA, ILLINOIS, JUNE, 1923

IN RECOGNITION

The Soil Survey of Illinois was organized under the supervision of the late Dr. Cyril G. Hopkins. The work progressed for eighteen years under his guidance and the first eighteen soil reports bear his name as senior author. On October 6, 1919, Dr. Hopkins died in a foreign land in the service of the American Red Cross. It is the purpose to carry on to completion this great work of the Illinois Soil Survey in the spirit, and along the same general plan and lines of procedure, in which it was begun.

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INTRODUCTORY NOTE

It is a matter of common observation that soils vary tremendously in their productive power, depending upon their physical condition, their chemical composition, and their biological activities. For any comprehensive plan of soil improvement looking toward the permanent maintenance of our agricultural lands, a definite knowledge of the various existing kinds or types of soil is a first essential. It is the purpose of a soil survey to classify the various kinds of soil of a given area in such a manner as to permit definite characterization for description and for mapping. With the information that such a survey affords, every farmer or land owner of the surveyed area has at hand the basis for a rational system of improvement of his land. At the same time the Experiment Station is furnished an inventory of the soils of the state, upon which intelligently to base plans for those fundamental investigations so necessary for solving the problems of practical soil improvement.

This county soil report is one of a series reporting the results of the soil survey which, when completed, will cover the state of Illinois. Each county report is intended to be as nearly complete in itself as it is practicable to make it, even at the expense of some repetition. There is presented in the form of an Appendix a general discussion of the important principles of soil fertility, in order to help the farmer and land owner to understand the significance of the data furnished by the soil survey and to make intelligent application of the same in the maintenance and improvement of the land. In many cases it will be of advantage to study the Appendix in advance of the soil report proper.

Data from experiment fields representing the more extensive types of soil, and furnishing valuable information regarding effective practices in soil management, are embodied in form of a Supplement. This Supplement should be referred to in connection with the descriptions of the respective soil types found in the body of the report.

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LIVINGSTON COUNTY SOILS

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SUPPLEMENT

LIVINGSTON COUNTY SOILS

BY J. G. MOSIER, S. V. HOLT, F. A. FISHER, E. E. DE TURK, AND H. J. SNIDER
PREPARED FOR PUBLICATION BY L. H. SMITH[1]

LOCATION AND CLIMATE OF LIVINGSTON COUNTY

Livingston county is located in the northeast quarter of Illinois. Its north boundary lies 102 miles south of the Wisconsin state line, and its east boundary 39 miles west of the Indiana line. The county is made up of 28½ townships, embracing an area of a little more than 1,000 square miles. It lies entirely within the geological area known as the early Wisconsin glaciation. Practically all the land is tillable and over 90 percent of the soil is of prairie formation.

The climate of Livingston county is characterized by a wide range between the extremes of winter and summer. The greatest range of any year from 1887 to 1920 was 136 degrees, in 1887. The lowest temperature recorded was -26°; the highest, 110°. The average date of the last killing frost in spring is May 1; the earliest in fall, October 13. The length of the growing season therefore is about 164 days.

The average annual precipitation for the county from 1887 to 1920 was 32.18 inches. The average rainfall by months for this period was as follows: January, 2.22 inches; February, 1.73; March, 2.64; April, 3.28; May, 3.85; June, 3.34; July, 2.88; August, 2.82; September, 3.36; October, 2.11; November, 2.14; December, 1.81. The proportion of total rainfall occurring during each season was: winter, 17.9 percent; spring, 30.4 percent; summer, 28.1 percent; autumn, 23.6 percent.

AGRICULTURAL PRODUCTION

Livingston county is to be regarded as distinctly agricultural, with almost the entire county tillable land. In 1920, as shown by the Fourteenth Census of the United States, there were 3,726 farms, these farms having an average of 170.9 acres each, 165.5 acres of which were improved. Of these farms, 65.6 percent were operated by tenants, which was a decrease in tenantry of 6.5 percent in ten years and 14.4 percent in the last twenty years. According to this report, the average value of land is $312.79 per acre, it ranking among the first five counties of the state in this respect.

The principal crops are corn, oats, wheat, pasture, hay, and clover. Small amounts of rye, barley, and potatoes are grown. The Census reports the following as the acreage and yield of the more important crops. It must be remembered that these figures are for but a single year—that of 1919.

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[1]J. G. Mosier, in charge of soil survey mapping (Professor Mosier died November 10, 1922, after partially preparing this report); S. V. Holt and F. A. Fisher, in charge of field party; E. E. De Turk, in charge of soil analysis; H. J. Snider, in charge of experiment fields; L. H. Smith, in charge of publications.

Crops	*Acreage*	*Production*
Corn	258,890	10,079,598 bu.
Oats	206,029	6,492,160 bu.
Wheat	25,084	422,657 bu.
Timothy	6,108	6,198 tons
Timothy and clover mixed	7,187	8,676 tons
Clover alone	10,015	11,349 tons
Alfalfa	1,505	3,592 tons
Silage crops	2,411	19,264 tons
Corn for forage	1,696	3,760 tons

The acreage of pasture is not given by the Census, but from other data it is found to be approximately 100,000. Within the past few years the soybean has been introduced, and this crop is gradually becoming established as one of the staple crops of the region. Likewise, the great value of sweet clover has recently become recognized, and it is rapidly taking its place among the more important crops of the county.

The live-stock interests, including those of the dairy, are of considerable importance, as is shown by the following data, also taken from the Census of 1920.

Animals and animal products	*Number*	*Value*
Horses	30,196	$3,195,405
Mules	1,870	237,229
Beef cattle	13,655	991,359
Dairy cattle	26,946	1,703,367
Sheep	7,115	95,418
Swine	53,542	1,165,914
Poultry	466,533	470,628
Eggs and chickens	.....	1,120,361
Dairy products	.....	808,347

The report gives the total value of the live stock as more than 10½ million dollars.

Fruit growing is of very little importance in this county. About 32,000 quarts of small fruits were produced in 1919. The total production of apples, pears, peaches, and cherries amounted to about 4,800 bushels, and the total crop of grapes was approximately 91,000 pounds.

SOIL FORMATION

The most important period in the geological history of the county from the standpoint of soil formation was the Glacial period, during which the material that later formed the soils was being deposited. At that time, snow and ice accumulated in the region of Labrador and to the west of Hudson Bay to such an amount that the mass pushed outward from these centers, chiefly southward, until a point was reached where the ice melted as rapidly as it advanced. In moving across the country from the far north, the ice gathered up all sorts and sizes of material, including clay, silt, sand, gravel, boulders, and even immense masses of rock. Some of these materials were carried for hundreds of miles and rubbed against surface rocks and against each other until largely ground into powder. When, thru the melting of the ice, the limit of advance was reached, the material carried by the glacier accumulated in a broad, undulating ridge or moraine. When the ice melted more rapidly than the

glacier advanced, the terminus of the glacier would recede and the material would be deposited somewhat irregularly over the area previously covered.

During the Glacial period at least six distinct ice advances occurred that were separated by long periods of time. They are described as follows, in the order of their occurrence:

(1) The Nebraskan, which did not touch Illinois; (2) the Kansan, which covered the western parts of Hancock and Adams counties; (3) the Illinoisan, which covered all of the state except the northwest county (Jo Daviess), the southern part of Calhoun county, and the seven southernmost counties; (4) the Iowan, which covered a part of northern Illinois, the exact area, however, being difficult to determine because of the effect of the subsequent glaciations; (5) the early Wisconsin, which covered the northeastern part of the state as far west as Peoria and as far south as Shelbyville; (6) the late Wisconsin, which extended to the west line of McHenry county and south to the town of Milford in Iroquois county.

The material transported by the glacier varied with the character of the rocks over which it passed. Granites, sandstones, limestones, shales, etc., were torn from their lodging places by the enormous denuding power of the ice sheet and ground up together. A pressure of forty pounds per square inch is exerted by a mass of ice one hundred feet thick, and these ice sheets were hundreds or possibly thousands of feet in thickness. The material carried along in the ice, especially the boulders and pebbles, became powerful agents for grinding and wearing away the surface over which the ice passed. Preglacial ridges and hills were rubbed down, valleys were filled with the debris, and the surface features were changed entirely. The mixture of materials deposited by the glacier is known as boulder clay, till, glacial drift, or simply drift. The average depth of this deposit over the state of Illinois is estimated as 115 feet.

Previous to the ice invasion, this region generally was not well suited to agriculture because of its rough and hilly character, as is shown by borings which indicate many preglacial valleys that later were filled with drift. The general effect of the glaciers was to change the surface from hilly to gently undulating. Only a few streams have done anything to change the topography, and these in only very limited areas. Most of the streams formerly flowed in broad, swampy sloughs rather than in distinct valleys.

THE GLACIATIONS OF LIVINGSTON COUNTY

Livingston county was entirely covered by the Illinoisan glacier, which partially leveled the region by rubbing down the hills and filling the valleys. The county was covered by a deposit of boulder clay. This glacier receded, and a long period elapsed, during which a soil was formed from the glacial material that had been deposited. This is the Sangamon soil and it is found only in deep borings, as when drilling wells. The Iowan glacier followed, but so far as is known, it did not touch this county. The early Wisconsin glacier came next, and covered the Illinoisan drift, building up three moraines.

The first or oldest moraine is the Minonk ridge, which is a part of the Bloomington morainic system. This ridge is from one to three miles wide and

crosses the southwest part of the county (see drainage map). The next moraine to be formed was the Cayuga-Chatsworth ridge, which is really one moraine, tho it is sometimes spoken of as two. It is not very distinct and is broken thru by the Vermilion river. It divides into two ridges for a short distance in the south part of the county in Township 25 North, Range 8 East, but unites again in Ford county. The largest and most important moraine of the county is the Marseilles, which enters the county in Township 30 North, Range 5 East, swings to the southeast and east and leaves the county in Township 29 North, Range 8 East. This ridge is from eight to ten miles wide and rises 75 to 100 feet above the land at the outer margin of the Cayuga-Chatworth moraine. It was pushed against the Cayuga moraine where for some distance the two moraines apparently form a single ridge.

The glacial drift is very much like that of other counties in this region. It consists of blue boulder clay containing beds or pockets of gravel and sand which form the source of the water supply. Altho rock outcrops occur along the Vermilion river, the average thickness of the drift is nearly 150 feet. The greatest depth of drift found thus far is in the south part of the town of Odell, where it is 360 feet deep. Three and one-half miles southwest of Odell the drift is 300 feet deep. Leverett, who has studied extensively the geology of this region, says, "There appear to be buried valleys traversing the county whose rock floors are 150 to 200 feet below the general level of the rock surface. In such valleys the drift is 300 feet in thickness."

THE ACTION OF WIND AND WATER

The deposit of glacial drift does not form the material of the present soil except in small areas. The rock flour produced by the grinding action of the glaciers has been reworked by the wind and deposited over practically all of the county to a depth of 12 to 40 inches. This wind-blown, or loessial, material now covering the level and less rolling areas, has been transformed into soil by weathering and the accumulation of organic matter. There is little doubt but that this wind-blown material was at one time fairly uniformly deposited over the exposed surface, but it has subsequently been removed in places by erosion, so that the boulder clay is exposed on some of the more rolling areas.

During the melting of the glacier the streams draining this area were frequently flooded, moving large amounts of rather coarse material, such as sand and gravel. This was deposited in the valleys, partly filling them. Later the streams cut down thru the fill, leaving gravel terraces. This gravel was afterward covered with the fine material that now constitutes the soil. These terraces occur principally along the Vermilion river. During the melting of the late Wisconsin glacier in northern Indiana and southern Michigan, some of the flood waters came westward across Iroquois, Ford, and Livingston counties, finding their way into the Vermilion river and thence into the Illinois. These floods formed the broad terraces in Townships 27 and 28 North, Ranges 5 and 6 East. The terrace area ends at the rock ridge which is exposed in the bottom of the river in Section 21, northwest of Pontiac.

A large glacial lake, known as Glacial Lake Morris, which formerly covered a very large part of Grundy county and extended south into the north-

eastern part of Livingston county in Township 30 North, Ranges 7 and 8 East, was responsible for the deposition of the large amount of black clay loam in that region.

PHYSIOGRAPHY AND DRAINAGE

In general Livingston county varies in topography from flat to rolling. There is no large amount of hilly land in the county, and the small area that does exist is found as bluffs along the bottom land of the Vermilion river. The variations in topography are due to three causes—the action of streams, of glaciers, and of wind. The latter, so far as it has modified topography, has been of no consequence except in the region north of Pontiac, where a few low sand dunes have been produced by the wind.

All the land of the county drains into the Illinois river, but thru various streams. The northeastern part, comprizing about eight townships, is drained by tributaries of the Mazon river; about twelve sections in the southwest corner have their outlet thru the Mackinaw river; while the remainder of the county, which forms a broad, flat valley, is drained by the Vermilion

MAP SHOWING THE DRAINAGE BASINS OF LIVINGSTON COUNTY WITH MORAINAL, INTERMORAINAL, AND TERRACE AREAS

river. Formerly, much of the county was swampy, and contained many ponds that rarely became dry. The extent of these areas is indicated generally by the amount of black clay loam. This district, with the aid of dredge ditches to furnish the outlets, has been thoroly tile-drained and now constitutes excellent agricultural land. The crest of the Marseilles moraine forms the divide between the Mazon river and the Vermilion river. The Minonk ridge is the divide between the Vermilion and Mackinaw rivers.

The altitude of Livingston county varies from 831 feet to less than 600. The following figures give the altitudes of certain places in the county. Ancona, 630 feet; Blackstone, 738; Budd, 705; Campus, 653; Cayuga, 691; Charlotte, 668; Chatsworth, 736; Cornell, 629; Dwight, 641; Emington, 701; Eylar, 698; Fairbury, 686; Flanagan, 676; Forrest, 688; Graymont, 657; Healey, 718; Lodemia, 658; Long Point, 641; Manville, 617; McDowell, 652; Missal, 668; Nevada, 680; Odell, 721; Pontiac, 647; Risk, 747; Rowe, 642; Saunemin, 686; Saxony, 696; Scovel, 694; Smithdale, 624; Strawn, 768; Sunbury, 660; Swygert, 737; Wilson, 615; Wing, 658. The altitude of the Marseilles moraine is from 740 to 755 feet. The highest point in the county, which is 831 feet, lies in the Cayuga ridge, in Section 5, Township 25 North, Range 8 East.

SOIL TYPES

The soils of Livingston county are divided into the following groups:

(a) *Upland Prairie Soils,* including the upland soils that have not been covered with forests, at least for any great length of time, and on which the luxuriant growth of prairie grasses has produced relatively large amounts of organic matter.

(b) *Upland Timber Soils,* including nearly all the upland areas that are now, or were formerly, covered with forests.

(c) *Terrace Soils,* including bench lands, or second bottom lands, formed by deposits from overloaded streams; and gravel outwash plains formed by broad sheets of water arising from the melting of the glaciers.

(d) *Swamp and Bottom-Land Soils,* including the overflow lands or flood plains along streams, the swamps, and the poorly drained lowlands.

(e) *Residual Soils,* including rock outcrop areas, and soils formed in place thru weathering of rocks.

Table 1 gives a list of the soil types found in Livingston county, the area of each type in square miles and in acres, and also its percentage of the total area. For example, we learn from the table that brown silt loam occupies about 775 square miles, or a little more than 496,000 acres, and that this type constitutes practically 75 percent of the total area of the county. The accompanying map shows the location and boundary of each type of soil, even down to areas of a few acres.

For explanations concerning the classification of soils and the interpretation of the map and tables, the reader is referred to the first part of the Appendix to this report.

TABLE 1.—SOIL TYPES OF LIVINGSTON COUNTY, ILLINOIS

Soil type No.	Name of type	Area in square miles	Area in acres	Percent of total area
	(a) Upland Prairie Soils (900, 1100)			
−26	Brown silt loam	775.04	496,026	75.265
−20	Black clay loam	163.79	104,826	15.906
−60	Brown sandy loam	9.85	6,304	.956
−28.1	Brown silt loam on tight clay	15.74	10,074	1.529
−20.2	Gravelly black clay loam	.32	205	.031
−28	Brown-gray silt loam on tight clay	1.01	646	.099
−26.4	Brown silt loam on gravel	.27	173	.026
−26.5	Brown silt loam on rock	.14	89	.013
		966.16	618,343	93.825
	(b) Upland Timber Soils (900, 1100)			
−34	Yellow-gray silt loam	18.92	12,109	1.838
−35	Yellow silt loam	2.07	1,325	.202
−64	Yellow-gray sandy loam	.22	141	.021
		21.21	13,575	2.061
	(c) Terrace Soils (1500)			
−27	Brown silt loam over gravel	13.39	8,570	1.300
−66	Brown sandy loam over gravel	2.27	1,453	.220
−20	Black clay loam	1.27	813	.123
−36	Yellow-gray silt loam over gravel	1.87	1,197	.181
−26.4	Brown silt loam on gravel	.59	378	.057
−61	Black sandy loam	.05	32	.005
−67	Yellow-gray sandy loam over gravel	.26	166	.026
−28	Brown-gray silt loam on tight clay	.14	89	.013
−68	Brown-gray sandy loam on tight clay	.07	45	.007
		19.91	12,743	1.932
	(d) Late Swamp and Bottom-Land Soils (1400)			
−54	Mixed loam	20.96	13,414	2.036
−26	Deep brown silt loam	.50	320	.048
−01	Deep peat	.88	563	.085
−02	Medium peat on clay	.05	32	.005
−13.6	Muck on marl	.01	6	.001
		22.40	14,335	2.175
	(e) Residual Soil (000)			
−98	Stony loam	.02	13	.002
	(f) Miscellaneous			
	Rock quarries and gravel pits	.05	32	.005
	Total	1,029.75	659,041	100.000

INVOICE OF PLANT FOOD IN LIVINGSTON COUNTY SOILS

SOIL ANALYSIS

The composition reported in the accompanying tables is, for the more extensive types, the average of several analyses. These analyses show that soils, like most things in nature, are variable; but for general purposes the average may be considered sufficient to characterize the soil type.

The chemical analysis of a soil, obtained by the methods here employed, gives the invoice of the total stock of the several plant-food materials actually present in the soil strata sampled and analyzed, but it should be understood that

the rate of liberation, as explained in the Appendix (page 33), is governed by many factors.

For convenience in making practical application of the chemical analyses the results have been translated from the percentage basis and are presented here in terms of pounds per acre. In this, the assumption is made that for ordinary types a stratum of dry soil 6⅔ inches thick weighs 2,000,000 pounds. It is recognized that this value is only an approximation, but it is believed that it will suffice for the purposes intended. It is, of course, a simple matter to convert these figures back to the percentage basis in case one desires for any purpose to consider the information in that form.

THE SURFACE SOIL

In Table 2 are reported the amount of organic carbon (which serves as a measure of the organic matter), and the total quantities of nitrogen, phosphorus, sulfur, potassium, magnesium, and calcium contained in 2 million pounds of the surface soil (the plowed soil of an acre about 6⅔ inches deep) of each type in Livingston county.

Because of the extreme variations frequently found within a given soil type with respect to the presence of limestone and acidity, no attempt is made to include in the tabulated results figures purporting to represent the average amounts of these substances present in the respective types. Such averages cannot give the farmer the specific information he needs regarding the lime requirements of a given field. Fortunately, however, very simple tests which can be made at home will furnish this important information, and these tests are described on pages 35 and 36 of the Appendix.

The variation among the different types of soil of Livingston county with respect to the content of important plant-food elements is very marked. For example, the deep peat contains, in the plowed soil of an acre, more than fifteen times as much nitrogen as the yellow-gray sandy loam. Comparing the deep peat with the most common type in the county, we find about five times as much nitrogen in it as in the brown silt loam, while on the other hand the brown silt loam contains nearly five times as much potassium as is found in the deep peat. The supply of phosphorus in the surface soil varies from 640 pounds per acre in the yellow-gray sandy loam over gravel to 2,010 pounds in the deep peat. A sulfur content of only 200 pounds per acre is found in the yellow-gray sandy loam over gravel, while in an equal volume of deep peat the analysis shows 2,500 pounds of this element. The magnesium varies in the different types from less than 3,000 to more than 16,000 pounds, and the calcium content ranges from 3,500 to nearly 40,000 pounds per acre.

It is important to note that some of the plant-food elements are present in very limited quantities as compared with crop requirements. Some simple computations are of interest in this connection. Assume, for example, that a four-field crop rotation of wheat, corn, oats, and clover yields 50 bushels of wheat per acre, 100 bushels of corn, 100 bushels of oats, and 4 tons of clover hay. These are high yields, but not impossible for they are sometimes obtained. It will be found that the most prevalent upland soil of Livingston county, the brown silt

LEGEND

- 900 Early Wisconsin Moraines
- 1100 Early Wisconsin Intermorainal

(a) UPLAND PRAIRIE SOILS

- 26 Brown silt loam
- 20 Black clay loam
- 60 Brown sandy loam
- Brown silt loam on tight clay
- 1120 Gravelly black clay loam
- 26 Brown-gray silt loam on tight clay
- Brown silt loam on gravel
- Brown silt loam on rock

(b) UPLAND TIMBER SOILS

- Yellow-gray silt loam
- 35 Yellow silt loam
- Yellow-gray sandy loam

(c) 1500 TERRACE SOILS

- Brown silt loam over gravel
- Brown sandy loam over gravel
- 20 1520 Black clay loam
- 1536 Yellow-gray silt loam over gravel
- 1528A Brown silt loam on gravel
- 1561 Black sandy loam
- 67 1567 Yellow-gray sandy loam over gravel
- 28 1528 Brown-gray silt loam on tight clay
- Brown-gray sandy loam on tight clay

(d) 1400 LATE SWAMP AND BOTTOM-LA

- 1454 Mixed loam
- 1426 Deep brown silt loam
- Deep peat
- Medium peat on clay
- Muck on marl

(e) 000 RESIDUAL SOIL

- 098 Stony loam

TABLE 2.—PLANT FOOD IN THE SOILS OF LIVINGSTON COUNTY, ILLINOIS: SURFACE SOIL
Average pounds per acre in 2 million pounds of surface soil (about 0-6⅔ inches)

Soil type No.	Soil type	Total organic carbon	Total nitrogen	Total phosphorus	Total sulfur	Total potassium	Total magnesium	Total calcium
	(a) Upland Prairie Soils (900, 1100)							
926 1126	Brown silt loam	63 770	5 130	1 050	1 000	38 010	9 590	10 840
1120	Black clay loam	64 100	5 790	1 470	1 100	39 730	16 090	20 270
1160	Brown sandy loam	40 400	3 330	650	780	27 500	4 630	6 680
928.1 1128.1	Brown silt loam on tight clay	55 690	4 730	1 080	950	41 870	11 490	9 740
1120.2	Gravelly black clay loam	87 120	7 960	1 780	1 640	29 160	12 880	22 660
1128	Brown-gray silt loam on tight clay	44 160	3 700	1 020	720	45 580	9 180	11 240
1126.4	Brown silt loam on gravel	44 060	3 740	1 060	860	35 380	8 260	8 440
1126.5	Brown silt loam on rock	48 380	4 620	1 260	300	28 720	6 580	10 400
	(b) Upland Timber Soils (900, 1100)							
1134	Yellow-gray silt loam	36 740	3 310	1 200	850	38 120	6 480	8 910
1135	Yellow silt loam	20 620	1 900	1 100	600	38 920	5 960	8 260
1164	Yellow-gray sandy loam	23 280	1 740	840	660	28 180	4 060	6 140
	(c) Terrace Soils (1500)							
1527	Brown silt loam over gravel	33 940	3 000	880	640	33 120	5 920	7 360
1566	Brown sandy loam over gravel	42 540	3 900	1 040	900	32 540	5 960	8 100
1520	Black clay loam	See figures for upland black clay loam (1120)						
1536	Yellow-gray silt loam over gravel	43 990	4 310	1 380	760	34 200	5 080	9 970
1526.4	Brown silt loam on gravel	34 940	3 280	960	940	35 120	8 380	9 080
1561	Black sandy loam	73 500	6 300	1 520	1 200	29 760	9 000	15 660
1567	Yellow-gray sandy loam over gravel	29 320	2 520	640	200	39 240	2 880	5 980
1528	Brown-gray silt loam on tight clay	70 380	6 980	1 300	640	38 720	5 300	11 700
1568	Brown-gray sandy loam on tight clay	43 600	3 420	740	720	25 260	4 120	8 660
	(d) Late Swamp and Bottom-Land Soils (1400)							
1454	Mixed loam[1]	....	....	....	....	....	....	....
1426	Deep brown silt loam	85 300	6 820	1 540	1 340	46 140	13 700	16 860
1401	Deep peat[2]	301 870	27 040	2 010	2 500	8 290	5 520	39 790
1402	Medium peat on clay[2]	161 290	13 890	1 380	2 220	15 690	7 180	17 800
1413.6	Muck on marl[3]	197 900	16 460	1 040	1 740	2 280	9 590	2 630
	(e) Residual Soils (000)							
098	Stony loam							

LIMESTONE AND SOIL ACIDITY.—In connection with these tabulated data it should be explained that the figures for limestone content and soil acidity are omitted, not because of any lack of importance of these factors but rather because of the peculiar difficulty of presenting in general averages adequate information concerning the limestone requirement. The limestone requirement for soils is extremely variable. It may vary from farm to farm and even from field to field. Therefore no attempt is made to include in these tables figures purporting to represent for the various types the limestone content or the soil acidity present. The need for limestone should be determined on every farm and for each field individually. Fortunately this can be easily done by the simple tests described in the Appendix to this report, pages 35 and 36.

[1]On account of the heterogeneous character of mixed loam, chemical analyses are not included for this type.
[2]These amounts are based upon the assumption that the surface stratum contains 1 million pounds of soil, an estimate which is, of course, very crude.
[3]Based on an estimate of 1½ million pounds of soil per acre.

TABLE 3.—PLANT FOOD IN THE SOILS OF LIVINGSTON COUNTY, ILLINOIS: SUBSURFACE SOIL
Average pounds per acre in 4 million pounds of subsurface soil (about 6⅔-20 inches)

Soil type No.	Soil type	Total organic carbon	Total nitrogen	Total phosphorus	Total sulfur	Total potassium	Total magnesium	Total calcium
	(a) Upland Prairie Soils (900, 1100)							
926, 1126	Brown silt loam..........	74 710	6 480	1 580	1 380	78 900	25 770	19 510
1120	Black clay loam..........	67 730	6 380	2 350	1 300	81 190	34 640	38 540
1160	Brown sandy loam.........	47 980	4 340	1 120	1 280	55 220	12 390	18 100
928.1, 1128.1	Brown silt loam on tight clay..................	44 330	4 970	1 310	1 350	91 310	37 610	16 970
1120.2	Gravelly black clay loam...	78 360	6 720	2 560	1 680	63 680	26 320	38 800
1128	Brown-gray silt loam on tight clay..............	35 840	3 920	1 560	640	100 280	28 560	20 280
1126.4	Brown silt loam on gravel..	59 200	5 560	1 880	1 160	70 600	19 840	15 480
1126.5	Brown silt loam on rock....	63 160	6 520	2 040	480	56 760	17 640	25 840
	(b) Upland Timber Soils (900, 1100)							
1134	Yellow-gray silt loam......	21 920	2 700	1 820	1 060	80 680	19 580	15 280
1135	Yellow silt loam..........	18 560	1 920	2 000	400	81 160	19 960	16 680
1164	Yellow-gray sandy loam....	11 080	1 080	1 480	720	56 600	7 920	9 440
	(c) Terrace Soils (1500)							
1527	Brown silt loam over gravel	57 560	5 160	1 720	1 080	68 560	15 120	16 720
1566	Brown sandy loam over gravel.................	61 440	5 880	1 800	1 480	66 120	13 960	15 320
1520	Black clay loam..........	See figures for upland black clay loam (1120)						
1536	Yellow-gray silt loam over gravel.................	32 300	4 060	1 900	780	69 820	13 120	16 420
1526.4	Brown silt loam on gravel..	55 200	5 960	1 680	1 640	71 120	20 560	17 520
1561	Black sandy loam.........	70 800	5 920	2 240	1 960	59 840	17 400	24 320
1567	Yellow-gray sandy loam over gravel............	18 720	2 400	1 200	680	62 840	9 720	12 720
1528	Brown-gray silt loam on tight clay..............	31 040	3 520	2 040	760	81 760	13 000	19 980
1568	Brown-gray sandy loam on tight clay..............	30 240	3 360	1 120	520	53 280	7 160	13 760
	(d) Late Swamp and Bottom-Land Soils (1400)							
1454	Mixed loam[1]............	......	......	......	......	......	......	......
1426	Deep brown silt loam......	95 040	8 920	2 040	1 520	89 320	31 600	24 120
1401	Deep peat[2]............	742 540	56 840	3 060	51 960	10 340	9 860	61 560
1402	Medium peat on clay[2].....	285 920	24 420	1 840	5 760	32 020	16 520	36 860
1413.6	Muck on marl............	117 240	9 560	1 840	3 320	65 160	40 200	85 560
	(e) Residual Soils (000)							
098	Stony loam..............							

LIMESTONE AND SOIL ACIDITY.—See note in Table 2.

[1]On account of the heterogeneous character of mixed loam, chemical analyses are not included for this type.
[2]Amounts reported are for 2 million pounds of deep peat and medium peat.

loam, contains only enough total nitrogen in the plowed soil, that is, in the surface stratum, 0 to 6⅔ inches, for the production of such yields to supply about ten rotations.

With respect to phosphorus, the condition differs only in degree, this soil containing no more of that essential element than would be required for about fourteen crop rotations yielding at the rates suggested above. On the other

TABLE 4.—PLANT FOOD IN THE SOILS OF LIVINGSTON COUNTY, ILLINOIS: SUBSOIL
Average pounds per acre in 6 million pounds of subsoil (about 20-40 inches)

Soil type No.	Soil type	Total organic carbon	Total nitrogen	Total phosphorus	Total sulfur	Total potassium	Total magnesium	Total calcium
	(a) Upland Prairie Soils (900, 1100)							
926, 1126	Brown silt loam	31 830	3 770	2 050	1 450	139 120	80 270	105 870
1120	Black clay loam	30 910	3 630	3 070	1 050	131 540	75 270	96 570
1160	Brown sandy loam	26 100	2 490	1 080	1 290	82 440	19 080	18 990
928.1, 1128.1	Brown silt loam on tight clay	22 820	3 800	2 100	2 250[1]	170 400	93 580	85 680
1120.2	Gravelly black clay loam	42 600	4 020	2 700	1 260	91 260	42 120	57 900
1128	Brown-gray silt loam on tight clay	24 240	3 360	2 640	1 020	157 080	61 920	40 200
1126.4	Brown silt loam on gravel	29 400	3 600	2 100	1 260	110 220	54 420	75 960
	(b) Upland Timber Soils (900, 1100)							
1134	Yellow-gray silt loam	19 710	3 150	3 420	1 140	145 740	49 950	23 340
1135	Yellow silt loam	20 460	2 220	3 240	300	107 640	109 200	170 400
1164	Yellow-gray sandy loam	15 060	1 320	2 400	1 620	89 940	18 180	14 160
	(c) Terrace Soils (1500)							
1527	Brown silt loam over gravel	35 820	4 320	2 160	1 020	103 740	34 500	23 340
1566	Brown sandy loam over gravel	28 740	3 840	2 040	1 740	94 020	25 440	22 620
1520	Black clay loam	See figures for upland black clay loam (1120)						
1536	Yellow-gray silt loam over gravel	18 270	3 870	3 240	1 020	99 720	29 100	26 220
1526.4	Brown silt loam on gravel	52 500	6 180	2 640	1 260	114 300	38 340	26 640
1561	Black sandy loam	27 360	3 240	2 520	1 860	91 020	26 880	35 700
1567	Yellow-gray sandy loam over gravel	9 840	2 220	2 220	480	86 340	23 700	13 940
1528	Brown-gray silt loam on tight clay	24 360	4 260	3 240	1 260	122 520	29 340	28 800
1568	Brown-gray sandy loam on tight clay	19 980	2 760	1 380	540	83 160	29 700	20 160
	(d) Late Swamp and Bottom-Land Soils (1400)							
1454	Mixed loam[2]	......	......	......	......	......	......	......
1426	Deep brown silt loam	62 100	6 420	2 280	1 020	147 000	48 480	28 620
1401	Deep peat[3]	889 800	69 600	2 820	153 570	14 220	19 050	154 350
1402	Medium peat on clay[4]	457 710	34 410	1 620	13 680	42 810	25 560	52 470
1413.6	Muck on marl	70 500	4 140	2 700	3 780	95 520	90 540	588 480
	(e) Residual Soils (000)							
098	Stony loam							

LIMESTONE AND SOIL ACIDITY.—See note in Table 2.

[1]One sample contained 51,780 pounds of sulfur per acre, which figure is excluded from the average for the type. See explanation on page 18.
[2]On account of the heterogeneous character of mixed loam, chemical analyses are not included for this type.
[3]Amounts reported are for 3 million pounds of deep peat.
[4]Amounts reported are for 3 million pounds, the same as for deep peat. For explanation see page 27.

hand the amount of potassium in the surface layer of this common soil type is equivalent to that which would be used in 472 years of such cropping provided the total crops were to be removed from the land; or, in case only the grain

were removed, this amount of potassium would supply such crops for about 30 centuries.

These general statements relating to the total quantities of these plant-food materials in the plowed soil of the most prevalent type in the county certainly emphasize the fact that the supplies of some of these necessary elements of fertility are extremely limited when measured by the needs of large crop yields for even one or two generations of people.

THE SUBSURFACE AND SUBSOIL

In Tables 3 and 4 are recorded the amounts of plant food in the subsurface and the subsoil of the different types. It should be remembered, however, that these supplies are of little value unless the top soil is kept rich. These tables also show great stores of potassium in the prevailing types of soil but only limited amounts of nitrogen and phosphorus, in agreement with the data for the corresponding surface samples.

DESCRIPTION OF INDIVIDUAL SOIL TYPES

(a) UPLAND PRAIRIE SOILS

The upland prairie soils of Livingston county cover 966.16 square miles, or 93.8 percent of the area of the county. They usually occupy the less eroded areas of the upland. They are black or brown in color owing to their high organic-matter content. This land was originally covered with prairie grasses, the partially decayed roots of which have been the main source of the organic matter. The flat, poorly drained areas contain the greater amounts of organic matter owing to the more luxuriant growth of the grasses that grew on such areas and to the excessive moisture in the soil which provided conditions better adapted for the preservation of their roots.

Brown Silt Loam (926, 1126)

Brown silt loam is the most extensive type in Livingston county. It covers an area of 775.04 square miles, or practically 75 percent of the area of the county. In topography it varies from flat to slightly rolling. The more rolling phase is found in the northeast part of the county and on the Marseilles moraine.

While the brown silt loam is primarily a prairie type, timber has recently invaded it to a slight extent in some localities. The trees found on the timbered brown silt loam are usually bur oak, wild cherry, black walnut, ash, and elm, but their occupation of the soil has not been sufficiently long to change its character to any great extent.

In general the various strata of this type are formed from wind-blown loessial material, from boulder clay, or from material deposited in shallow water. A peculiar phase of the brown silt loam in this county is found on the moraines, where as a consequence of the removal of part of the fine loessial material the glacial drift is encountered at less than 30 inches from the surface; sometimes it even outcrops. On the steeper parts of the moraines erosion has taken place to such an extent that the brown soil is nearly all washed away and these areas,

if of sufficient size, are mapped as a different type, such as yellow silt loam (–35) if very steep, or yellow-gray silt loam (—34) if not so steep. Many such areas are too small to be represented on the map. In general the brown silt loam of the moraines (926), containing as it does less organic matter than the average, is affected to some extent by the tighter subsoil formed by the glacial drift. If the drift is rather compact, as is occasionally the case, the subsoil is somewhat inferior, owing to interference with drainage. This condition is indicated by a grayish color appearing after the soil becomes dry following a rain. Fortunately, however, this condition does not occur very frequently nor does it include large areas, since most of the glacial drift is pervious and some is even gravelly.

Large areas of the county were at one time covered by temporary lakes. In these lakes a deposit of rather fine-grained clay was made which was later covered by ordinary soil material. In this way a rather heavy subsoil was formed somewhat to the detriment of the drainage. This heavy phase merges into the condition represented by the type mapped as brown silt loam on tight clay (—28.1), a typical area of which occurs on Cayuga ridge.

The surface soil, 0 to 6⅔ inches, is a brown silt loam varying from a yellowish brown on the more rolling areas to a dark brown or black on the more nearly level and poorly drained tracts. In physical composition it varies to some extent, but it normally contains from 55 to 75 percent of the different grades of silt. In the lower areas the proportion of clay is usually higher than on the more rolling parts, where a perceptible amount of sand may occur. With the flooding of some parts of the county during the time of the melting of the glacier, more or less sand was carried in and deposited on the shores of the flooded parts. Some of this sand was later carried to the higher lands by the wind and became mixed with the soil, forming a sandy loam or a sandy phase of the silt loam.

The organic-matter content of the surface soil varies from 4 to 7 percent, depending on topography, and averages about 5.4 percent, or 54 tons per acre. In small areas on the more rolling parts of the moraines erosion has occurred to such an extent that the organic matter is rather low.

The natural subsurface is represented by a stratum which varies from 4 to 18 inches in thickness. This variation is due either to erosion, or to the fact that shallower-rooting grasses usually grew on the higher and better drained land, or perhaps to both of these causes. Erosion has removed some of the surface soil from the steeper parts and deposited it on the lower land, thus leaving a thinner layer of the dark soil in one case and producing a thicker one in the other. The physical composition of the subsurface varies in somewhat the same manner as the surface soil. In some parts, especially on the moraines, glacial till constitutes a part or all of the subsurface. The organic-matter content of the subsurface (6⅔ to 20 inches) is about 3.1 percent, or 62 tons per acre. In color this stratum varies from a dark brown or almost black to a yellowish brown, always changing to a lighter color with increasing depth.

The natural subsoil begins at a depth of 12 to 22 inches and extends to an indefinite depth. It varies from a yellow to a drabbish yellow, silty, clayey material, sometimes composed partially or even wholly of boulder clay. In the flat areas, however, not subject to erosion but where material has been

washed in from the higher surrounding land, the subsoil to a depth of 40 inches may not reach the boulder clay. The average depth to till is about 36 inches.

Management.—When the virgin brown silt loam was first cropped it was in fine tilth, it worked easily, and large crops could be grown with much less work than now. Continuous cropping to corn or to corn and oats, with the burning of corn stalks, stubble, grass, and even straw in many cases, has in a great measure destroyed the tilth, so that the soil becomes more difficult to work, washes badly, runs together, and bakes more readily than formerly. Unless the moisture conditions are very favorable, the ground will plow up cloddy, with the result that unless well-distributed rains follow, a good seed bed is difficult to produce. The clods may remain all season. Much plant-food material will be locked up in them, and the best results cannot be obtained. This condition of poor tilth may become serious if the present methods of management continue; in some cases it is already one of the factors that limit crop yields. The remedy is to use a rotation which includes a clover crop and to increase the organic-matter content by plowing under every available form of vegetable material, such as farm manure, corn stalks, straw, clover, stubble, and even weeds. Fresh organic matter is not only of great value in improving the physical condition of this type of soil, but it is also important because of its nitrogen content. Furthermore, as it decays it liberates mineral plant-food elements such as potassium, of which there is an inexhaustible supply in the soil, and phosphorus from the phosphate contained in or applied to the soil.

The deficiency of organic matter in the soil is shown by the way the fall-plowed land runs together during the winter, or at any time when heavy rains occur. In the spring following fall plowing, the land should be disked early and deep for the purpose of conserving moisture, raising the temperature, and making plant food available.

On most of the brown silt loam in Livingston county, limestone is already becoming deficient in the upper strata, altho it usually exists in considerable quantity in the subsoil. If the tests for carbonates and acidity described in the Appendix, pages 35 and 36, indicate the need of limestone, or if because of lime deficiency such crops as sweet clover and alfalfa fail to grow well, an application of about 2 tons of limestone per acre is recommended.

Rock phosphate has been used on many farms in Livingston county with apparently very beneficial results. The results of the field experiments in the use of this material will be found in the Supplement. In applying rock phosphate not less than one-half ton per acre should be used as the initial application, with a half-ton for each subsequent crop rotation. Under such treatment the phosphorus content of the soil will be gradually increased so that the time will come when the applications may be discontinued for a time. At just what point the law of diminishing returns comes into effect remains for experience to determine.

Suggestions for practical systems of cropping will be found in the discussion of crop rotations in the Appendix, on page 42. For the results of actual field experiments in improving the soil of the brown silt loam type the reader is referred to pages 45 to 54 of the Supplement.

Black Clay Loam (920, 1120)

Black clay loam represents the flat prairie land that was formerly swampy. It is sometimes called "gumbo" because of its sticky character. Its occurrence in the flat, poorly drained areas is due to the accumulation of organic matter and to the washing in of clay and fine silt from the higher areas.

Black clay loam presents many variations. It may change with a difference of only a foot or two in elevation. In this county, as elsewhere, the boundary lines between the black clay loam and the brown silt loam are not always distinct. Sometimes on the border between these two types the subsoil is distinctly that of black clay loam, while the surface soil is very silty, or is a good brown silt loam. The washing in of silty material from the surrounding higher lands, especially near the edges of the areas, modifies the character of the soil, giving it a brown silt loam surface. With the annual cultivation of the soil, this change is taking place more rapidly now than formerly when washing was largely prevented by prairie grasses. Many small areas of black clay loam in the more rolling parts are being slowly buried by this process.

This type is very widely distributed over the county, as is shown by the fact that, aside from the timber and terrace areas where this type would be expected to occur only rarely, there are but ten sections that do not have an area of black clay loam large enough to map. It occurs in areas that were formerly sloughs and ponds, and even in the small kettle-hole ponds on the moraines, altho most of these are so small that they cannot be shown on the map. There are many large areas of the type, as in Township 30 North, Ranges 7 and 8 East, Township 27 North, Range 7 East, and a strip eight or ten miles wide west of the Vermilion river. Altogether this type covers an area of 163.79 square miles, or about 16 percent of the total area of the county.

The surface soil, 0 to 6⅔ inches, is a black, plastic, granular, clay loam varying locally to a black clayey silt loam, or even to a black sandy clay loam which may contain gravel. These variations in physical composition occur as the type merges into other types. In some places that were formerly sloughs, the water has deposited gravel in sufficient abundance to form what is mapped as gravelly black clay loam (—20.2). Recent erosion has occasionally covered the black clay loam with several inches of dark or black, silty material, which often makes it difficult to draw the soil boundary. If erosion continues, as it undoubtedly will, the soil boundary may be changed entirely by the burying of the black clay loam with brown silt loam. The organic-matter content varies from 5.1 to 10.6 percent, with an average of 6.2 percent or 62 tons per acre. The organic matter in the kettle-hole depressions on the moraines is sometimes very high.

The natural subsurface stratum has a thickness of 10 to 20 inches. It varies from a black to a brownish drab clay loam and is usually somewhat heavier than the surface soil. It grades into a dull yellow or a drabbish or olive-colored material with increasing depth. The average organic-matter content of the stratum sampled (6⅔ to 20 inches) is about 3 percent, or 60 tons per acre. The stratum is usually rather pervious to water, owing to jointing or checking from shrinkage in times of drouth, to the penetration of plant roots, and to the action of crayfish and other animals. Some exceptions to this are

found where it grades toward brown-gray silt loam on tight clay (1128) and brown silt loam on tight clay (1128.1). Here the lower strata become somewhat impervious and drainage is slow.

The subsoil to a depth of 40 inches varies in composition from a clayey silt to a very heavy clay, and in color from a dull drabbish yellow to drab or olive. Areas of the heavier phase are found in Townships 29 and 30 North, Ranges 4 and 5 East. Because of poor natural drainage, the iron in the subsoil is not highly oxidized. Concretions of calcium carbonate are frequently found. The perviousness of the subsoil is about the same as that of the subsurface and is due to the same causes. When thrown out on the surface where wetting and drying may take place, this clayey material soon breaks into small, irregular masses about one-fourth to one-half inch square in section.

Management.—Drainage is the first requirement in the management of this type and, if the outlet is obtainable, this may usually be effected with little difficulty. Thoro drainage helps to keep the soil in good physical condition.

After the organic matter is necessarily destroyed by the process of nitrification, and after the limestone is removed by cropping and leaching, the physical condition of the soil becomes poorer, and as a consequence more difficult to work. Both organic matter and limestone tend to develop granulation and mellowness, which are very essential with heavy soils. The organic matter should be maintained by turning under manure and such crop residues as corn stalks and straw, and by the use of clover and pasture in rotations.

In many cases the use of limestone will probably be of little or no value on this soil because the subsoil and subsurface are naturally charged with carbonates, and in some instances even the surface soil contains carbonates. Because of exceptions to these conditions, however, it is recommended that the tests for acidity and carbonates described in the Appendix, pages 35 and 36, be made; and if carbonates are not found within a foot of the surface, a moderate application of limestone, about 2 tons per acre, should be made.

Altho the black clay loam is one of the most productive soils in the state, it has a tendency to shrink and expand to such a degree as to be objectionable at times, especially during drouth. This results in the formation of cracks, which are sometimes as much as two or more inches in width at the surface and extend with lessening width to two or three feet in depth. These cracks allow the soil to dry out rapidly, and as a result the crop is injured thru lack of moisture. They do much damage by "blocking out" hills of corn and severing the roots. While cracking may not be prevented entirely, good tilth with a soil mulch will do much toward that end. Cultivation is more essential on this type, both for aeration and for the conservation of moisture, than on almost any other type in the county. It must be remembered, however, that cultivation should be as shallow as possible in order to prevent injury to the roots of the growing crop. (See Bulletin 181.)

Occasional small patches of alkali soil are found in areas of black clay loam. These spots are indicated by the fact that oats lodge badly and corn makes a poor growth, usually turning yellow or brown. If the amount of alkali is large, the corn may not grow to a height of more than two or three feet and will have a bushy appearance. Even if it reaches almost normal

height, it does not produce much grain. The fragments of shells that are frequently found are indications of alkali. A sweet clover crop turned under is probably the best remedy. Good underdrainage should be provided.

Brown Sandy Loam (960, 1160)

The brown sandy loam of the upland is confined principally to four areas, as follows: Townships 29 and 30 North, Range 8 East; Township 28 North, Range 8 East; Township 25 North, Ranges 7 and 8 East; and Township 28 North, Range 5 East. In the formation of this type it seems probable that at one time the sand was laid down on the shore lines of old lakes and was later reworked to some extent by the wind. Other types of soil lying in proximity to the brown sandy loam contain more sand than normally occurs. The total area of brown sandy loam in the county is 9.85 square miles or 6,304 acres.

The surface soil, 0 to 6⅔ inches, is a brown sandy loam varying in color from light brown to black, and in physical composition from a loam with about 50 percent of sand to a very sandy loam carrying 75 percent, or slightly more, of sand. A representative sample would contain from 60 to 65 percent of sand, mostly of medium grade. Many small areas of sand are found in this type but they are too small to be shown separately on the map. The organic-matter content is about 3.2 percent, or 32 tons per acre.

The natural subsurface stratum varies in thickness from 7 to 12 inches, and in color from dark brown to brownish yellow, usually passing into a yellow sandy silt or silty sand in the lower part of the stratum. In physical composition it varies even more than the surface layer. The organic-matter content of the stratum sampled (6⅔ to 20 inches) is about 1.7 percent, or 34 tons per acre.

The subsoil varies both in color and in physical composition. The color may be a bright yellow under conditions of good drainage, or a grayish yellow where the water table has been rather high. In composition, it may be sand, sandy silt, or sandy clayey silt.

Management.—The type is not very well supplied with plant food. In order to increase the nitrogen and organic matter, legumes must be grown, manure should be applied, and crop residues plowed under. Before clovers can be grown at their best, limestone to the amount of 2 or 3 tons per acre should be applied.

According to the analytical data given in Tables 2, 3, and 4, brown sandy loam is among the poorest in phosphorus of all the soil types in the county, which fact suggests that sooner or later provision must be made for correcting this deficiency. Unfortunately the Experiment Station has no experiment field on this particular soil type from which information might be drawn regarding the best form of phosphatic material to apply. The low organic content of this type of soil would suggest a possible advantage in using a directly available form of phosphate, such as steamed bone meal or acid phosphate. One hundred pounds of steamed bone meal or 200 pounds of acid phosphate of good quality will return to the soil as much of the element phosphorus as is contained in 50 bushels of wheat or 70 bushels of corn. Alfalfa and soybeans ought to do well on this soil.

Brown Silt Loam on Tight Clay (928.1, 1128.1)

Brown silt loam on tight clay occurs on the northern half of Cayuga ridge in broken or disconnected areas. The type covers an area of 15.74 square miles, or 1.5 percent of the area of the county.

The surface soil, 0 to 6⅔ inches, is a brown silt loam which shows a gray color when it dries after a rain. The color is not uniform but varies so as to give the field a spotted appearance. The stratum contains about 4.8 percent of organic matter, or 48 tons per acre.

The natural subsurface soil is a layer from 4 to 18 inches thick consisting of a brown silt loam which passes into a compact, brownish yellow, impervious material. The stratum sampled (6⅔ to 20 inches) contains about 1.9 percent of organic matter.

The subsoil consists of yellowish or drabbish yellow compact material that does not permit the ready passage of air or water. The origin of this tight subsoil is difficult to explain. A similar case occurs in Iroquois county, where there is little doubt but that the subsoil was deposited in a shallow lake. One possible explanation is that the material composing this tight stratum may have been deposited during a period of recession of the glacier. When the glacier advanced, this material was pushed forward, and upon the melting of the ice was deposited upon the moraine, where it has been subsequently covered by a few inches of wind-blown material which now constitutes the soil.

One of the samples of subsoil collected showed an extremely high sulfur content amounting to 51,780 pounds per acre. Upon resampling this area, a thin deposit of white substance was found at a depth of 35 to 40 inches which, upon chemical examination, appeared to be calcium sulfate. Since this seemed to be a local abnormality, the sulfur determination for this sample is excluded from the average given in Table 4.

Management.—This type is lacking in limestone in the upper two strata, but the subsoil seems to contain a considerable supply of this material. For legumes, it is therefore necessary to apply limestone. Sweet clover is the best legume to grow, as its roots have the greatest power of penetration, even greater than those of alfalfa.

Gravelly Black Clay Loam (1120.2)

Much of the black clay loam contains some gravel, but only in a few places is the gravel sufficiently abundant to form the type, gravelly black clay loam, in areas large enough to be shown as such on the map. Small areas of an acre or two are frequently met. The type occurs principally in places that were formerly sloughs containing streams which at times became swift currents. The total area of gravelly black clay loam as mapped is 205 acres, and it is confined mostly to Township 27 North, Range 6 East.

The surface soil, 0 to 6⅔ inches, is a black, granular, plastic, gravelly clay loam with some sand. The content of gravel varies from 20 to 30 percent. Most of the pebbles are smaller than a half inch in diameter. This stratum contains about 7.5 percent of organic matter, or 75 tons per acre.

The natural subsurface is a layer from 8 to 14 inches in thickness. It differs but little from the surface except that it becomes lighter in color with in-

creasing depth until it passes into a drab or a grayish yellow. The organic matter of the sample collected (6⅔ to 20 inches) was approximately 3.4 percent, or 68 tons per acre.

The natural subsoil, extending to 40 inches, is somewhat more variable than the other strata but is usually a silty clay with sand and gravel. It contains about 1.2 percent of organic matter.

Management.—This type is well supplied with the elements of plant food. It should be managed in the same manner as the black clay loam (-20).

Brown-Gray Silt Loam on Tight Clay (928, 1128)

Brown-gray silt loam on tight clay is widely scattered over the county, but it usually occurs in small areas. Many spots of this type, too small to be shown on the map, are included in areas of brown silt loam (—26). These spots usually occur as shallow depressions. The total area in this county, as mapped, amounts to just about one square mile.

The surface soil, 0 to 6⅔ inches, varies from a grayish brown to brown silt loam. It contains about 3.8 percent of organic matter, or 38 tons per acre.

The natural subsurface is a layer from 6 to 12 inches thick. It is a gray to brownish gray silt loam with about 1.5 percent of organic matter in the stratum sampled (6⅔ to 20 inches).

The subsoil is a brownish yellow clay, tough, plastic, and impervious.

Management.—Drainage is very necessary in the improvement of this type, but the impervious character of both subsurface and subsoil makes this land rather difficult to drain. The lines of tile must be placed much closer than in the draining of brown silt loam (—26).

The type is rather meagerly supplied with the elements of plant food and it appears to be acid in the surface stratum. The growing of legumes and the turning under of manure and crop residues will supply nitrogen, but in order to secure the best growth of legumes limestone should be applied. Sweet clover is recommended as one of the best crops to grow. After these needs are satisfied probably phosphorus will prove to be beneficial.

Brown Silt Loam on Gravel (1126.4)

Brown silt loam on gravel occurs only in Sections 13 and 14 in Township 27 North, Range 7 East, where a gravel ridge has been covered with silt. The total area is only 173 acres.

The surface soil, 0 to 6⅔ inches, is a brown silt loam with some sand. It has about 3.8 percent of organic matter, or 38 tons per acre.

The subsurface soil, 6⅔ to 20 inches, is a brown to brownish yellow silt loam, containing about 2.5 percent of organic matter.

The subsoil is made up chiefly of gravel, which first appears at depths varying from 16 to 30 inches.

Management.—The management of the type should be the same as that recommended for brown silt loam (—26) except that, on account of the relatively shallow reservoir for holding moisture, a large amount of organic matter is even more essential than on brown silt loam. For the same reason early maturing crops should be grown.

Brown Silt Loam on Rock (1126.5)

The total area of brown silt loam on rock in the county is 89 acres and it is found in Sections 15 and 16, Township 28 North, Range 5 East. The rock is limestone.

The surface soil, 0 to 6⅔ inches, is a brown silt loam with about 4.2 percent of organic matter, or 42 tons per acre.

The subsurface is sampled to 20 inches in depth where possible. Rock is found at depths varying from 15 to 30 inches. The subsurface as sampled contains about 2.7 percent of organic matter.

Management.—Shallow soils underlain by rock usually do not withstand drouth to any great extent; therefore in the management of this type it would be well to use early maturing crops, as these will be affected least by drouth. In other respects the type should be managed about the same as the ordinary brown silt loam (—26). If the soil is very shallow it will probably be best to give the land over to permanent pasture.

(b) UPLAND TIMBER SOILS

The upland timber soils include nearly all the upland areas that are now, or have been, covered with forests. These soils contain much less organic matter than those of the prairie. In forests the vegetable material from trees accumulates upon the surface and is either burned or suffers almost complete decay. Grasses, which furnish large amounts of humus-forming roots, do not grow to any extent because of the shade. Moreover, the organic matter that had accumulated before the timber began growing is removed thru various decomposition processes, with the result that in these soils generally the content of nitrogen and organic-matter has become too low for the best growth of farm crops.

The total area of upland timber soils in Livingston county is 21.21 square miles, or about 2 percent of the area of the county.

Yellow-Gray Silt Loam (934, 1134)

Yellow-gray silt loam is not very extensive in this county, altho it is distributed along most of the courses of the larger streams, where it forms a narrow belt on either side. The type as mapped includes some narrow, steep slopes along the bottom lands of streams, that are really yellow silt loam but are too narrow to be shown as such on the map. In topography, it is undulating to slightly rolling and usually has good surface drainage. White oak and hickory are trees commonly found. The area covered by this type is 18.92 square miles. or about 12,000 acres.

The surface soil, 0 to 6⅔ inches, is a gray or yellowish gray silt loam, incoherent and mealy, but not granular. In physical composition it varies according to its relation to other types. Where it occurs in the sandy loam areas it sometimes becomes somewhat sandy, and very small areas may contain enough sand to be mapped as yellow-gray sandy loam. The organic-matter content averages about 2.7 percent, or 27 tons per acre. The amount increases where the type grades into the brown silt loam which usually borders it.

The natural subsurface stratum varies from 3 to 10 inches in thickness. In color it is gray, grayish yellow, or yellow. It is somewhat pulverulent, but becomes more coherent and plastic with increasing depth. The amount of organic matter of the stratum sampled (6⅔ to 20 inches) is about .9 percent.

The subsoil is a yellow or grayish yellow clayey silt or silty clay, somewhat plastic when wet but pervious to water. Sometimes the subsoil is made up wholly or in part of glacial material.

Management.—In the management of yellow-gray silt loam, one of the essential considerations is the maintenance or increase of organic matter. This is even more necessary with the yellow-gray silt loam than with the brown silt loam because of the fact that this soil is naturally much lower in organic matter, having only about one-half as much as the brown silt loam. The deficiency in organic matter permits the soil particles to run together, in the wetting by heavy rains. Organic matter will help to prevent washing on the more rolling areas. As it decays, it supplies nitrogen and at the same time tends to liberate other plant-food elements, as explained in the Appendix.

In the areas sampled, the soil is acid, thus making it necessary to apply 2 or 3 tons of ground limestone per acre before the best results can be obtained with legumes. Later applications may be smaller. The growth of legumes is very essential since they furnish organic matter to turn back into the soil and at the same time supply the necessary nitrogen. But all forms of organic matter, such as corn stalks, manure, and weeds are of value and they should be turned into the soil rather than burned.

On the experiment field in Lake county representing this soil type, excellent results have been obtained by the use of steamed bone meal.

Yellow Silt Loam (935, 1135)

Yellow silt loam is found on steep slopes along the streams and on the steepest parts of moraines. It covers an area of 1,325 acres.

The surface soil, 0 to 6⅔ inches, consists of a yellow to brownish yellow silt loam varying in composition from a sandy phase on the one hand, to a rather heavy phase on the other. The surface stratum contains about 3.2 percent of organic matter, or 32 tons per acre.

The subsurface is a yellow silty or sandy material varying toward a silty clay. The stratum contains about one percent of organic matter.

The subsoil is a yellow clayey silt and in many cases is formed from boulder clay.

This type is usually not under cultivation and practically the only way in which it can be used is as pasture or as woodland.

Yellow-Gray Sandy Loam (964, 1164)

With only a few exceptions, yellow-gray sandy loam occurs adjacent to the streams in a manner similar to yellow-gray silt loam. The type is usually slightly rolling. It covers an area of 141 acres.

The surface soil, 0 to 6⅔ inches, is a gray to yellow-gray sandy loam containing about 2 percent of organic matter, or 20 tons per acre.

The subsurface is a sandy loam varying in color from yellow to grayish yellow. It contains .5 percent of organic matter.

The subsoil varies considerably, being made up in some places of a yellowish, sandy, clayey material, while in others it is composed of boulder clay, and in still others of sand.

Management.—As a type, yellow-gray sandy loam is somewhat inferior to most other soils of the county. It is low in practically all elements of fertility. In the samples analyzed, carbonates were lacking even in the subsoil. Where such a condition exists, 2 to 4 tons of limestone per acre should be applied so that legumes will grow well. The legumes should be turned under in order to increase the amount of nitrogen, which is now much too low for a productive soil. All organic residues should be put back into the soil for the same purpose. The type is low in phosphorus, and ultimately this element must be supplied if the best results are to be obtained in the growth of crops. The same remarks regarding phosphorus apply here as are given in connection with brown sandy loam (—60).

(c) TERRACE SOILS

The terrace soils in this county were formed by the flooding of a valley during the melting of the glacier. The stream carried large amounts of coarse sand and gravel which were deposited as its velocity decreased. Finer material later deposited over this sand and gravel forms the present soil. When the stream reached its normal size after the glacier had melted, it cut down thru the deposit so deep that the terrace is no longer flooded at times of overflow. The depth of the finer material that forms the soil varies in this county from about 16 inches to four or five feet. The value of these soils depends much upon the depth to gravel. If the gravel is too near the surface, the crops may suffer from drouth. The total area of terrace soils in Livingston county is about 20 square miles.

Brown Silt Loam over Gravel (1527)

Brown silt loam over gravel is found along the Vermilion river above the rock ledge or rock ridge which the river crosses just below Pontiac. The topography is usually flat to undulating. The total area is 13.39 square miles, or 1.3 percent of the area of the county.

The surface soil, 0 to 6⅔ inches, is a little lighter in color than the upland brown silt loam. It varies somewhat in composition, being distinctly sandy in some places. It contains about 2.9 percent of organic matter, or 29 tons per acre.

The natural subsurface consists of a silt loam stratum varying from 6 to 12 inches in thickness. It varies in color from brown to light brown. The stratum sampled (6⅔ to 20 inches) contains about 2.5 percent of organic matter, or 50 tons per acre.

The subsoil varies from a yellow silt to a yellow sandy silt. In most instances gravel is found at a depth of 30 to 48 inches. This provides good drainage where the water table is sufficiently low.

Management.—In the samples examined, all strata of this type were acid. In cases where this is the condition, 2 or 3 tons of limestone will be required

as an initial application in order to provide favorable conditions for the growth of legumes. Later applications should be made in quantity sufficient to maintain these conditions. The same need for applying phosphorus and for turning under legumes and organic residues exists in this type as in the upland brown silt loam. Excellent results have been obtained in the use of rock phosphate in building up land on this soil type.

Brown Sandy Loam over Gravel (1566)

Brown sandy loam over gravel occurs along the Vermilion river. It owes its formation to the same general processes as the preceding type (1527). It includes a total area of 1,453 acres.

The surface soil, 0 to 6⅔ inches, is a brown sandy loam varying on the one hand to brown silt loam, and on the other to sand. It contains about 3.8 percent of organic matter, or 38 tons per acre.

The subsurface is a brown sandy loam, passing into a yellowish sandy silt at a depth of about 15 inches. It contains about 1.6 percent of organic matter.

The subsoil is a yellow sandy silt varying to a silt. The gravel is sometimes found at a depth of less than 40 inches altho it usually occurs at greater depths.

Management.—In the sample analyzed, all strata were acid. Where this condition occurs it will be necessary to apply 2 or 3 tons of limestone to secure the best results with legumes. The same use must be made of organic residues and manure as recommended for the preceding type. The remarks made in connection with the management of brown sandy loam, page 17, will also apply here.

Black Clay Loam (1520)

A few areas of black clay loam occur in the poorly drained parts of the terrace. This type covers a total of 813 acres. It differs but little, if any, from the upland type of black clay loam. (See page 15.)

Yellow-Gray Silt Loam over Gravel (1536)

Yellow-gray silt loam over gravel occurs along the upper course of the Vermilion river and its two tributaries—Indian and Forrest creeks. The total area of the type is 1,197 acres.

The surface soil, 0 to 6⅔ inches, is a yellowish or grayish yellow silt loam varying in sand content to a loam and in some places even to a sandy loam.

The subsurface soil is a yellow silt loam.

The subsoil is a yellow silty clay or clayey silt, underlain by medium gravel, which is generally below 40 inches.

Management.—In the management of this type, one of the first requirements is an application of 2 to 3 tons of limestone in order to correct the acidity which in the subsoil becomes very high. The low content of organic matter demands that legumes be grown and that the best use be made of crop residues, and manure. Along with the improvement in this way, it would be of benefit to apply some form of phosphate—probably one of the more available forms,

such as bone meal or acid phosphate, would be preferable. This would be a good soil for alfalfa, as it is generally well drained owing to the underlying stratum of gravel.

Brown Silt Loam on Gravel (1526.4)

Brown silt loam on gravel occurs to a limited extent along Indian and Forrest creeks west of Forrest. It covers only 378 acres.

The surface soil, 0 to 6⅔ inches, is lighter in color than the upland brown silt loam. It contains about 3 percent of organic matter.

The subsurface soil is a yellowish brown or brownish yellow silt loam.

The subsoil is a yellow sandy or gravelly silt loam passing into gravel at a depth of about 16 to 28 inches.

Management.—This type requires the same treatment as brown silt loam on gravel of the upland (1126.4).

Black Sandy Loam (1561)

Black sandy loam occurs to the extent of only 32 acres.

The surface soil is a black sandy loam containing 6.3 percent of organic matter.

The subsurface soil is a sandy loam changing from black to drabbish yellow and carrying about 3 percent of organic matter.

The subsoil is a drabbish yellow sandy loam containing some coarse sand.

Management.—Good cultivation, together with the application of limestone when the soil becomes deficient in this constituent, is the essential thing in handling this land.

Yellow-Gray Sandy Loam over Gravel (1567)

Yellow-gray sandy loam over gravel occurs along the streams in a manner similar to that of brown sandy loam over gravel, but it has been timbered sufficiently long to reduce the organic matter to a very small amount. This type covers an area of 166 acres.

The surface soil, 0 to 6⅔ inches, is a gray to light yellow sandy loam. It ranges in texture from a loam to a very sandy phase of sandy loam. It contains about 2.5 percent of organic matter, or 25 tons per acre.

The subsurface soil is a gray or yellowish gray sandy loam, passing into the heavier phase characteristic of the subsoil at a depth of about 15 to 17 inches.

The subsoil consists usually of a sandy, clayey material that is underlain by gravel at a depth of 36 to 54 inches.

Management.—Since this type is very low in nitrogen, containing only 2,520 pounds per acre in the plowed soil, the growing of legumes should receive primary consideration. The soil as sampled indicates the absence of limestone; therefore it is necessary to apply 2 to 4 tons per acre in order to produce the best growth of legumes. All available organic residues and farmyard manure must be turned under in order to increase and maintain the supply of organic matter and nitrogen. This soil is also very low in phosphorus and this element should be supplied as recommended for brown sandy loam, page 17.

Brown-Gray Silt Loam on Tight Clay (1528)

Brown-gray silt loam on tight clay is rather common in the terrace, altho the total area mapped as such amounts to only 89 acres. The individual areas are small, and there are many spots corresponding to this type that are too small to be shown on the map. They constitute small depressions of gray soil that formerly were ponds.

The surface soil, 0 to 6⅔ inches, is a grayish brown silt loam containing 6 percent of organic matter, which is a rather high percentage for this type.

The natural subsurface stratum, which is about 10 inches thick, is very gray in color.

The natural subsoil, which immediately underlies the gray stratum, is heavy and tight, and this may in turn be underlain by sand.

Management.—The type is fairly well supplied with elements of plant food, but in the area sampled the soil is acid, thus indicating that limestone is necessary in order to get the best results with legumes. Probably phosphate would be profitably applied on these areas. Drainage is very essential but is rather difficult to secure.

Brown-Gray Sandy Loam on Tight Clay (1568)

In some places where tight clay has formed, sand has been carried to the area either by wind or water, and there is formed a brown-gray sandy loam on tight clay that has the same characteristics as the preceding type except that it is not so well supplied with the elements of plant food. There are 45 acres of the type.

The surface soil, 0 to 6⅔ inches, is a brownish gray to gray sandy loam containing about 2.9 percent of organic matter, or 29 tons per acre.

The subsurface is a gray sandy loam underlain at 14 to 17 inches by a tough, tight, plastic, sandy clay. The stratum as sampled (6⅔ to 20 inches) contains about 1.3 percent of organic matter.

The subsoil is a tough, impervious, sandy clay that is underlain by coarse sand at a depth of 36 to 48 inches.

Management.—This soil is low in plant food. In order to improve it, limestone should be applied, legumes should be grown, and all available manure and other forms of organic matter should be plowed under. Phosphorus should also be supplied. See recommendations for brown sandy loam, page 17.

(d) LATE SWAMP AND BOTTOM-LAND SOILS

This group includes the bottom lands along the streams, the swamps, and the poorly drained lowlands. Much of the soil, therefore, is of alluvial formation and the land is largely subject to overflow. The swamps occupy low, marshy places. In former times these swamps became, during wet seasons, shallow ponds or lakes. Five types of this group are recognized in Livingston county, the total area of which aggregates 22.40 square miles, or about 2.17 percent of the county.

Mixed Loam (1454)

The common type of bottom land of Livingston county is mixed loam. It occurs in irregular strips, rarely more than a quarter of a mile wide, along the Vermilion river and its tributaries and also along the west branch of the Mazon river. It covers a total area of 20.96 square miles, or 13,414 acres. This type is a mixture of types, as its name implies; black clay loam, brown silt loam, brown loam, brown sandy loam, and even sand may all be found. Even if it were possible to indicate on the map the many variations, the effort would be useless because the next flood would probably leave a different mixture.

The surface soil, 0 to 6⅔ inches, is a mixed loam varying from clay loam to sand and, as sampled, containing approximately 5.9 percent of organic matter, or 59 tons per acre.

The subsurface soil, 6⅔ to 20 inches, is a brown mixed loam with about 4.7 percent of organic matter, according to the sample taken.

The subsoil probably varies more than the other strata. As sampled it contains about 2.4 percent of organic matter.

Management.—The type is not of great importance except for pasture. The essential factor in its management is good cultivation. Renewal by frequent overflows will maintain the fertility.

Deep Brown Silt Loam (1426)

Deep brown silt loam occurs only to the extent of 320 acres, and is located principally along the branches of the Mazon river in the northeastern part of the county.

The surface soil, 0 to 6⅔ inches, is a brown silt loam containing about 7 percent of organic matter.

The subsurface soil, 6⅔ to 20 inches, consists of a brown silt loam containing more or less sand. The organic-matter content is about 4.1 percent.

The subsoil varies from a brown silt loam to a brownish yellow silt loam. It contains about 1.8 percent of organic matter.

Management.—This type is well supplied with all elements of plant food and the main consideration in its management at present is good cultivation. As time goes on attention should be given to the need for limestone.

Deep Peat (1401)

Most of the deep peat is found in Townships 25 and 26 North, Range 8 East, where it occurs in rather deep depressions in the moraine. The total area of the type is 563 acres.

The surface soil, 0 to 6⅔ inches, is a black to brown peat containing a considerable percentage of shells in some local areas. These give a decidedly alkaline character to the soil.

The subsurface soil, 6⅔ to 20 inches, is a brown to black peat.

The subsoil is a brown to black peat, varying in the shallower areas to clayey material which may form a part of the subsoil.

Management.—Drainage is the first requirement of this type. Some parts have been drained and crops have been grown. The type, however, is low in

the element potassium, as is characteristic of peat, and an application of some form of potassium will probably be necessary before success can be obtained with corn and oats. For the results of field experiments on deep peat, see page 54 of the Supplement.

Medium Peat on Clay (1402)

The area mapped as medium peat on clay amounts to only 32 acres. Altho mapped as medium peat on clay, which would presume the peat to be not more than 30 inches deep, in reality the thickness of the peaty layer is extremely variable. In some spots the clay occurs within a few inches of the surface, while at other places a boring of 60 inches reveals nothing but peaty material. Evidently the sample taken for chemical analysis was collected from one of these spots of deeper peat, as the high contents of carbon and nitrogen would indicate.

Management.—In general this land should receive the same management as that suggested for deep peat (1401).

Muck on Marl (1413.6)

The only area of muck on marl in this county occurs in the southeast quarter of Section 32, Township 30 North, Range 7 East.

The surface soil, 0 to 6⅔ inches, is a black clayey material containing about 23 percent of organic matter.

The subsurface and subsoil are not uniform, but are made up of layers of marl alternating with clayey material. The samples examined contained about 5 percent of organic matter in the subsurface and 2 percent in the subsoil.

Management.—This type should be managed in the same way as black clay loam (-20).

(e) RESIDUAL SOILS

A residual soil is one which has not been transported thru the action of glacier, wind, or water, but is formed *in place* by the weathering of rocks and the accumulation of organic matter. Rock outcrops are also included in this group.

Stony Loam (098)

The only area of stony loam in the county is found in Section 1, Township 27 North, Range 5 East. This is a small area where the underlying rock comes close to the surface. The shallow soil partakes of the character of brown silt loam and is mixed with loose pieces of the partially weathered rock. At the highest part of the area the bare rock is exposed, and from this extreme the type merges gradually into typical brown silt loam. This outcrop affords a source of excellent limestone for soil improvement. A sample gave a purity test of nearly 99 percent of calcium carbonate equivalent.

APPENDIX

EXPLANATIONS FOR INTERPRETING THE SOIL SURVEY

CLASSIFICATION OF SOILS

In order to intelligently interpret the soil maps, the reader must understand something of the method of soil classification upon which the survey is based. Without going far into details the following paragraphs are intended to furnish a brief explanation of the general plan of classification here used.

The unit in the soil survey is the soil type, and each type possesses more or less definite characteristics. The line of separation between adjoining types is usually distinct, altho sometimes one type grades into another so gradually that it is very difficult to draw the line between them. In such exceptional cases, some slight variation in the location of soil-type boundaries is unavoidable.

In establishing soil types several factors must be taken into account. These are: (1) the geological origin of the soil, whether residual, cumulose, glacial, eolial, alluvial, or colluvial; (2) the topography, or lay of the land; (3) the native vegetation, as prairie grasses or forest; (4) the depth and the character of the surface, the subsurface, and the subsoil, as to the percentages of gravel sand, silt, clay, and organic matter which they contain, their porosity, granulation, friability, plasticity, color, etc.; (5) the natural drainage; (6) the agricultural value, based upon its natural productiveness; (7) the ultimate chemical composition and reaction.

Great Soil Areas in Illinois.—On the basis of the first of the above mentioned factors, namely, the geological origin, the state of Illinois has been divided into seventeen great soil areas with respect to their geological formation. The names of these areas are given in the following list along with their corresponding index numbers, the use of which is explained below. For the location of these geological areas, the reader is referred to the general map published in Bulletins 123 and 193.

000 *Residual,* soils formed in place thru disintegration of rocks, and also rock outcrop
100 *Unglaciated,* comprizing three areas, the largest being in the south end of the state
200 *Illinoisan moraines,* including the moraines of the Illinoisan glaciations
300 *Lower Illinoisan glaciation,* covering nearly the south third of the state
400 *Middle Illinoisan glaciation,* covering about a dozen counties in the west-central part of the state
500 *Upper Illinoisan glaciation,* covering about fourteen counties northwest of the middle Illinoisan glaciation
600 *Pre-Iowan glaciation,* but now believed to be part of the upper Illinoisan
700 *Iowan glaciation,* lying in the central northern end of the state
800 *Deep loess areas,* including a zone a few miles wide along the Wabash, Illinois, and Mississippi rivers
900 *Early Wisconsin moraines,* including the moraines of the early Wisconsin glaciation
1000 *Late Wisconsin moraines,* including the moraines of the late Wisconsin glaciation
1100 *Early Wisconsin glaciation,* covering the greater part of the northeast quarter of the state
1200 *Late Wisconsin glaciation,* lying in the northeast corner of the state
1300 *Old river-bottom and swamp lands,* found in the older or Illinoisan glaciation
1400 *Late river-bottom and swamp lands,* those of the Wisconsin and Iowan glaciations
1500 *Terraces,* bench or second bottom lands, and gravel outwash plains
1600 *Lacustrine deposits,* formed by Lake Chicago, the enlarged glacial Lake Michigan

Mechanical Composition of Soils.—The mechanical composition, or the texture, is a most important feature in characterizing a soil. The texture depends upon the relative proportions of the following physical constituents:

Organic matter: undecomposed and partially decayed vegetable material
Inorganic matter: clay, silt, fine sand, sand, gravel, stones

Classes of Soils.—Based upon the relative proportion of the various constituents mentioned above, soils may be grouped into a number of well recognized classes. Following is a list of these classes, arranged according to their index numbers, the use of which is explained below:

Index Number Limits	Class Names
0 to 9	Peats
10 to 12	Peaty loams
13 to 14	Mucks
15 to 19	Clays
20 to 24	Clay loams
25 to 49	Silt loams
50 to 59	Loams
60 to 79	Sandy loams
80 to 89	Sands
90 to 94	Gravelly loams
95 to 97	Gravels
98	Stony loams
99	Rock outcrop

Naming and Numbering Soil Types.—The naming of soil types has been the subject of much discussion, and practice varies considerably in this matter. In this soil survey of Illinois a system of classification and naming has been adopted which is based upon the various considerations presented in the preceding paragraphs.

After texture, one of the most striking characteristics of a soil is the color. Therefore, in the naming of soils in Illinois, a combination of color and texture, together with other descriptive terms when necessary, has been adopted so that the name in itself carries a definite description of a given soil type; as for example, "gray silt loam on tight clay," or "brown silt loam over gravel." The use of the prepositions *on* and *over* serves to indicate the presence of certain substrata. When the surface soil is underlain with material such as sand, gravel, or rock, the word *over* is used if this material lies at a depth greater than 30 inches; if it is less than 30 inches, the word *on* is used.

For further identification of soil types a system of numbering, resembling somewhat the Dewey library system, has been adopted whereby each soil type is assigned a certain number. This number indicates at once the geological origin of the soil as well as its physical description. The digits of the order of hundreds represent the geological area where the soil is found, beginning with 000, the residual, followed by 100, the unglaciated, and the rest of the series in the order of the enumeration presented in the paragraph above headed *Great Soil Areas in Illinois.* The digits of the orders of units and tens represent the various kinds of soil such as are enumerated above in the list of soil classes. Certain modifications are designated in this system by a figure placed at the right of the decimal point. To illustrate the working of this numbering system, suppose a soil type bears the number 726.5. The number 7 indicates that this soil occurs in the Iowan glaciation, the 26 that it is a brown silt loam, and the .5 that rock

is found less than 30 inches below the surface. These numbers are especially useful in designating small areas on the map and as a check in reading the colors.

A complete list of the soil types occurring in each county, along with their corresponding type numbers and the area covered by each type, will be found in the respective county soil reports.

SOIL SURVEY METHODS

Mapping the Soil Types.—In conducting the soil survey, the county constitutes the unit of working area. In order that the survey be thoroly trustworthy it is necessary that careful, well-trained men be employed to do the mapping. The work is prosecuted to the best advantage by working in parties of from two to four. Only such men are placed in charge of these parties as are thoroly experienced in the work and have shown themselves to be especially well qualified in training and ability.

The men must be able to keep their location exactly and to recognize the different soil types, with their principal variations and limits, and they must show these upon the maps correctly. A definite system is employed in checking up this work. As an illustration, one man will survey and map a strip 80 rods or 160 rods wide and any convenient length, while his associate will work independently on another strip adjoining this area, and if the work is correctly done the soil-type boundaries will match up on the line between the two strips.

An accurate base map for field use is absolutely necessary for soil mapping. The base maps are prepared on a scale of one inch to the mile, the official data of the original or subsequent land survey being used as a basis in their construction. Each surveyor is provided with one of these base maps, which he carries with him in the field; and the soil-type boundaries, together with the streams, roads, railroads, canals, and town sites are placed in their proper locations upon the map while the mapper is on the area. Each section, or square mile, is divided into 40-acre plots on the map, and the surveyor must inspect every ten acres and determine the type or types of soil thereon. The different types are indicated on the map by different colors, pencils for this purpose being carried in the field.

A small auger 40 inches long forms for each man an invaluable tool with which he can quickly secure samples of the different strata for inspection. An extension for making the auger 80 inches long is taken by each party, so that any peculiarity of the deeper subsoil layers may be studied. Each man carries a compass to aid in keeping directions. Distances along roads are measured by a speedometer or by some other measuring device, while distances in the field away from the roads are determined by pacing, an art in which the men become expert by practice. The soil boundaries can thus be located with as high a degree of accuracy as can be indicated by pencil on the scale of one inch to the mile.

Sampling for Analysis.—After all the soil types of a county have been located and mapped, samples representative of the different types are collected for chemical analysis. For this purpose usually three strata are sampled; namely, the surface (0 to 6⅔ inches), the subsurface (6⅔ to 20 inches), and the subsoil

(20 to 40 inches). These strata correspond approximately, in the common kinds of soil, to 2,000,000 pounds of dry soil per acre in the surface layer, and to two times and three times this quantity in the subsurface and the subsoil, respectively. This is, of course, a purely arbitrary division, very useful in arriving at a knowledge of the quantity and the distribution of plant food in the soil, but it should be noted that these strata do not necessarily coincide with the natural strata as they actually exist in the soil, and which are referred to in describing the soil types.

By this system of sampling we have represented separately three zones for plant feeding. The surface layer includes at least as much soil as is ordinarily turned with the plow. This is the part with which the farm manure, limestone, phosphate, or other fertilizer applied in soil improvement is incorporated, and which must be depended upon in large part to furnish the necessary plant food for the production of crops. A rich subsoil has little or no value if it lies beneath a worn-out surface, but if the fertility of the surface soil is maintained at a high point, then the strong vigorous plants will have power to secure more plant food from the subsurface and subsoil.

PRINCIPLES OF SOIL FERTILITY

Probably no agricultural fact is more generally known by farmers and landowners than that soils differ in productive power. Even tho plowed alike and at the same time, prepared the same way, planted the same day with the same kind of seed, and cultivated alike, watered by the same rains and warmed by the same sun, nevertheless the best acre may produce twice as large a crop as the poorest acre on the same farm, if not, indeed, in the same field; and the fact should be repeated and emphasized that with the normal rainfall of Illinois the productive power of the land depends primarily upon the stock of plant food contained in the soil and upon the rate at which it is liberated, just as the success of the merchant depends primarily upon his stock of goods and the rapidity of sales. In both cases the stock of any commodity must be increased or renewed whenever the supply of such commodity becomes so depleted as to limit the success of the business, whether on the farm or in the store.

CROP REQUIREMENTS

Ten different elements of plant food are essential for the growth and formation of every plant. These elements are: *carbon, oxygen, hydrogen, nitrogen, phosphorus, sulfur, potassium, magnesium, calcium, and iron;* and they are represented by the chemical symbols: C, O, H, N, P, S, K, Mg, Ca, and Fe. Some seasons in central Illinois are sufficiently favorable to allow the production of at least 50 bushels of wheat per acre, 100 bushels of corn, 100 bushels of oats, and 4 tons of clover hay. When such crops, growing under favorable climatic and cultural conditions and uninjured by disease or insect pests, are not produced the failure is due to unfavorable soil condition, which may result from poor drainage, poor physical condition, or from an actual deficiency of plant food.

Table A shows the plant-food requirements of some of our most common field crops with respect to the seven elements furnished by the soil. The figures show the weight in pounds of the various elements contained in a bushel or in a

TABLE A.—PLANT FOOD IN WHEAT, CORN, OATS, AND CLOVER

Produce: Kind	Produce: Amount	Nitrogen	Phosphorus	Sulfur	Potassium	Magnesium	Calcium	Iron
		lbs.	*lbs.*	*lbs.*	*lbs.*	*lbs.*	*lbs.*	*lbs.*
Wheat, grain......	1 bu.	1.42	.24	.10	.26	.08	.02	.01
Wheat, straw.....	1 ton	10.00	1.60	2.80	18.00	1.60	3.80	.60
Corn, grain.......	1 bu.	1.00	.17	.08	.19	.07	.01	.01
Corn stover.......	1 ton	16.00	2.00	2.42	17.33	3.33	7.00	1.60
Corn cobs........	1 ton	4.00	.....	.....	4.00	.....	.....	.....
Oats, grain.......	1 bu.	.66	.11	.06	.16	.04	.02	.01
Oat straw........	1 ton	12.40	2.00	4.14	20.80	2.80	6.00	1.12
Clover seed.......	1 bu.	1.75	.50	.....	.75	.25	.13	.....
Clover hay.......	1 ton	40.00	5.00	3.28	30.00	7.75	29.25	1.00

ton, as the case may be. From these data the amount of any element removed from an acre of land by a crop of a given yield can easily be computed.

It needs no argument to show that the continuous removal of such quantities of plant food without provision for their replacement must result sooner or later in soil depletion.

PLANT-FOOD SUPPLY

Of the ten elements of plant food, three (*carbon, oxygen,* and *hydrogen*) are secured from air and water, and seven from the soil. *Nitrogen,* one of these seven elements obtained from the soil by all plants, may also be secured from the

TABLE B.—PLANT-FOOD ELEMENTS IN MANURE, ROUGH FEEDS, AND FERTILIZERS

Material	Pounds of plant food per ton of material		
	Nitrogen	Phosphorus	Potassium
Fresh farm manure..................	10	2	8
Corn stover..................	16	2	17
Oat straw..................	12	2	21
Wheat straw..................	10	2	18
Clover hay..................	40	5	30
Cowpea hay..................	43	5	33
Alfalfa hay..................	50	4	24
Sweet clover (water-free basis)[1]..................	80	8	28
Dried blood..................	280	...	...
Sodium nitrate..................	310	...	...
Ammonium sulfate..................	400	...	...
Raw bone meal..................	80	180	...
Steamed bone meal..................	20	250	...
Raw rock phosphate..................	...	250	...
Acid phosphate..................	...	125	...
Potassium chlorid..................	...	...	850
Potassium sulfate..................	...	...	850
Kainit..................	...	...	200
Wood ashes[2]..................	...	10	100

[1]Young second year's growth ready to plow under as green manure.
[2]Wood ashes also contain about 1,000 pounds of lime (calcium carbonate) per ton.

air by one class of plants (legumes), in case the amount liberated from the soil is insufficient; but even these plants (which include only the clovers, peas, beans, vetches, and alfalfa among our common agricultural plants) are dependent upon the soil for the other six elements (*phosphorus, potassium, magnesium, calcium, iron,* and *sulfur*), and they also utilize the soil nitrogen so far as it becomes soluble and available during their period of growth.

The vast difference with respect to the supply of these essential plant food elements in different soils is well brought out in the data of the Illinois soil survey. For example, it has been found that the nitrogen in the surface 6⅔ inches, which represents the plowed stratum, varies in amount from 180 pounds per acre to nearly 33,000 pounds. In like manner the phosphorus content varies from about 420 to 4,900 pounds, the potassium ranges from 1,530 to about 58,000 pounds. Similar variations are found in all of the other essential plant food elements of the soil.

With these facts in mind it is easy to understand how a deficiency of one of these elements of plant food may become a limiting factor of crop production. When an element becomes so reduced in quantity as to become a limiting factor of production, then we must look for some outside source of supply. Table B is presented for the purpose of furnishing information regarding the quantity of plant food contained in some of the materials most commonly used as sources of plant-food supply.

LIBERATION OF PLANT FOOD

The chemical analysis of the soil gives the invoice of fertility actually present in the soil strata sampled and analyzed, but the rate of liberation is governed by many factors, some of which may be controlled by the farmer, while others are largely beyond his control. Chief among the important controllable factors which influence the liberation of plant food are the choice of crops to be grown, the use of limestone, and the incorporation of organic matter. Tillage, especially plowing, also has a considerable effect in this connection.

Feeding Power of Plants.—Different species of plants exhibit a very great diversity in their ability to obtain plant food directly from the insoluble minerals of the soil. As a class, the legumes—especially such biennial and perennial legumes as red clover, sweet clover, and alfalfa—are endowed with unusual power to assimilate from mineral sources such plant foods as calcium and phosphorus, converting them into available forms of food for the crops that follow. For this reason it is especially advantageous to employ such legumes in connection with the application of limestone and rock phosphate. Thru their growth and subsequent decay large quantities of the mineral foods are liberated for the benefit of the cereal crops which follow in the rotation, and which are less independent feeders. Moreover, as an effect of the deep rooting habit of these legumes, large quantities of mineral plant-food elements are brought up and rendered available from the vast reservoirs of the lower subsoil.

Effect of Limestone.—Limestone corrects the acidity of the soil and thus encourages the development not only of the nitrogen-gathering bacteria which live in the nodules on the roots of clover, cowpeas, and other legumes, but also the nitrifying bacteria, which have power to transform the insoluble and unavailable organic nitrogen into soluble and available nitrate nitrogen. At the

same time, the products of this decomposition have power to dissolve the minerals contained in the soil, such as potassium and magnesium, and also to dissolve the insoluble phosphate and limestone which may be applied in low-priced forms. Thus, in the conversion of sufficient organic nitrogen into nitrate nitrogen for a 100-bushel crop of corn, the nitrous acid formed is alone sufficient to convert seven times as much insoluble tricalcium phosphate into soluble monocalcium phosphate as would be required to supply the phosphorus for the same crop.

Organic Matter and Biological Action.—Organic matter may be supplied by animal manures, consisting of the excreta of animals and usually accompanied by more or less stable litter; and by plant manures, including green-manure crops and cover crops plowed under, and also crop residues such as stalks, straw, and chaff. The rate of decay of organic matter depends largely upon its age, condition, and origin, and it may be hastened by tillage. The chemical analysis shows correctly the total organic carbon, which constitutes, as a rule, somewhat more than half the organic matter; so that 20,000 pounds of organic carbon in the plowed soil of an acre corresponds roughly to 20 tons of organic matter. But this organic matter consists largely of the old organic residues that have accumulated during the past centuries because they were resistant to decay, and 2 tons of clover or cowpeas plowed under may have greater power to liberate plant food than the 20 tons of old, inactive organic matter. The history of the individual farm or field must be depended upon for information concerning recent additions of active organic matter, whether in applications of farm manure, in legume crops, or in sods of old pastures.

The condition of the organic matter of the soil is indicated to some extent by the *ratio of carbon to nitrogen.* Fresh organic matter recently incorporated with the soil contains a very much higher proportion of carbon to nitrogen than do the old resistant organic residues of the soil. The proportion of carbon to nitrogen is higher in the surface soil than in the corresponding subsoil, and in general this ratio is wider in highly productive soils well charged with active organic matter than in very old, worn soils badly in need of active organic matter.

The organic matter furnishes food for bacteria, and as it decays certain decomposition products are formed, including much carbonic acid, some nitrous acid, and various organic acids, and these acting upon the soil have the power to dissolve the essential mineral plant foods, thus furnishing soluble phosphates, nitrates, and other salts of potassium, magnesium, calcium, etc., for the use of the growing crop.

Effect of Tillage.—Tillage, or cultivation, also hastens the liberation of plant food by permitting the air to enter the soil. It should be remembered, however, that tillage is wholly destructive, in that it adds nothing whatever to the soil, but always leaves it poorer, so far as plant food is concerned. Tillage should be practiced so far as is necessary to prepare a suitable seed bed for root development and also for the purpose of killing weeds, but more than this is unnecessary and unprofitable; and it is much better actually to enrich the soil by proper applications of limestone, organic matter and other fertilizing materials, and thus promote soil conditions favorable for vigorous plant growth, than to depend upon excessive cultivation to accomplish the same object at the expense of the soil.

PERMANENT SOIL IMPROVEMENT

According to the kind of soil involved, any comprehensive plan contemplating a permanent system of agriculture will need to take into account some of the following considerations.

The Application of Limestone

The Function of Limestone.—In considering the application of limestone to land it should be understood that this material functions in several different ways, and that a beneficial result may therefore be attributable to quite diverse causes. Limestone provides the plant food calcium, of which certain crops are strong feeders. It corrects acidity of the soil, thus making for some crops a much more favorable environment as well as establishing conditions absolutely required for some of the beneficial legume bacteria. It accelerates nitrification and nitrogen fixation. It promotes sanitation of the soil by preventing the growth of certain fungus diseases, such as corn root rot. Experience indicates that it modifies either directly or indirectly the physical structure of fine-textured soils, frequently to their great improvement.

Thus, working in one or more of these different ways, limestone often becomes the key to the improvement of worn lands. Remarkable success has been experienced with limestone used in conjunction with sweet clover in the reclamation of abandoned hill land which had been ruined thru erosion.

Amounts to Apply.—If the soil is acid, usually at least 2 tons per acre of ground limestone should be applied as an initial treatment. Continue to apply limestone from time to time according to the requirement of the soil as indicated by the tests described below, or until the most favorable conditions are established for the growth of legumes. In case the magnesium content of the soil is low, magnesian limestone ($CaCO_3MgCO_3$), which contains both calcium and magnesium and has slightly greater power to correct soil acidity, ton for ton, than the ordinary calcium limestone ($CaCO_3$) may be used. On strongly acid soils, or on land being prepared for alfalfa, 4 or 5 tons per acre of ground limestone may well be used for the first application.

How to Ascertain the Need for Limestone.—The need of a soil for limestone may be ascertained by applying the following test for soil acidity. Along with the acidity test, a test for the presence of carbonates should be made. It should be understood that a positive test for carbonates does not guarantee the absence of acid; for it may happen, especially when the soil is near the neutral point, that positive tests for both acidity and carbonates are obtained. This condition is explained by the assumption that solid particles of calcium or magnesium carbonates form centers of alkalinity within a soil that is generally acid. Because of this fact any test made of a given soil ought to be repeated if it is to be thoroly reliable. It is also desirable to test samples from different depths. Following are the directions for making these tests:

The Potassium Thiocyanate Test for Acidity. This test for soil acidity is made with a 4-percent solution of potassium thiocyanate in alcohol—4 grams of potassium thiocyanate in 100 cubic centimeters of 95-percent alcohol (not denatured). When a small quantity of soil shaken up in a test tube with this solution gives a red color the soil is acid and limestone should be applied. If the solution remains colorless the soil is not acid. An excess of water interferes with the test. In testing, therefore, the soil should not be wetter than it would be when in good tillable condition. The conditions for a prompt reaction require a temperature that is comfortably warm.

The Hydrochloric Acid Test for Carbonates. Make a shallow cup of a ball of soil and pour into it a few drops of concentrated hydrochloric acid. If carbonates are present they are decomposed with the liberation of carbon dioxid, which appears as gas bubbles, producing foaming or effervescence. With much carbonate present the action is lively, but with mere traces of it the bubbles are given off slowly. If no carbonate, or very little, is indicated by the test, then it is advisable to apply limestone.

The Nitrogen Problem

Nitrogen presents the greatest practical soil problem in American agriculture. Four important reasons for this are: its increasing deficiency in most soils; its cost when purchased on the open market; its removal in large amounts by crops; and its loss from soils thru leaching. Nitrogen costs from four to five times as much per pound as phosphorus. A 100-bushel crop of corn requires 150 pounds of nitrogen for its growth, but only 23 pounds of phosphorus. The loss of nitrogen from soils may vary from a few pounds to over one hundred pounds per acre, depending upon the treatment of the soil, the distribution of rainfall, and the protection afforded by growing crops.

An inexhaustible supply of nitrogen is present in the air. Above each acre of the earth's surface there are about sixty-nine million pounds of atmospheric nitrogen. The nitrogen above one square mile weighs twenty million tons, an amount sufficient to supply the entire world for four or five decades. This large supply of nitrogen in the air is the one to which the world must eventually turn.

There are two methods of collecting the inert nitrogen gas of the air and combining it into compounds that will furnish products for agricultural uses. *These are the chemical and the biological fixation of the atmospheric nitrogen.* Farmers have at their command one of these methods. By growing inoculated legumes, nitrogen may be obtained from the air, and by plowing under more than the roots of those legumes, nitrogen may be added to the soil.

Inasmuch as legumes are worth growing for feed and seed as well as for nitrate production, a considerable portion of the nitrogen thus gained may be considered a by-product. Because of that fact, it is questionable whether the chemical fixation of nitrogen, the possibilities of which now represent numerous compounds, will ever be able to replace the simple method of obtaining atmospheric nitrogen by growing inoculated legumes.

For easy figuring it may well be kept in mind that the following amounts of nitrogen are required for the produce named:

1 bushel of oats (grain and straw) requires 1 pound of nitrogen.
1 bushel of corn (grain and stalks) requires 1½ pounds of nitrogen.
1 bushel of wheat (grain and straw) requires 2 pounds of nitrogen.
1 ton of timothy contains 24 pounds of nitrogen.
1 ton of clover contains 40 pounds of nitrogen.
1 ton of cowpeas contains 43 pounds of nitrogen.
1 ton of alfalfa contains 50 pounds of nitrogen.
1 ton of average manure contains 10 pounds of nitrogen.
1 ton of young sweet clover, at about the stage of growth when it is plowed under as green manure, contains, on water-free basis, 80 pounds of nitrogen.

The roots of clover contain about half as much nitrogen as the tops, and the roots of cowpeas contain about one-tenth as much as the tops. Soils of moderate productive power will furnish as much nitrogen to clover (and two or three times as much to cowpeas) as will be left in the roots and stubble. In grain

crops, such as wheat, corn, and oats, about two-thirds of the nitrogen is contained in the grain and one-third in the straw or stalks.

The Phosphorus Problem

The element phosphorus is an indispensable constituent of every living cell. It is intimately connected with the life processes of both plants and animals, the nuclear material of the cells being especially rich in this element.

The phosphorus content of a soil varies according to its origin and the kind of farming practiced. Even virgin soils are found that are deficient in phosphorus.

It should always be borne in mind in connection with the application of phosphorus to the land that the addition of phosphorus, or of any other fertilizing substance, to the soil can exert no benefit until the need of it has become a limiting factor of production. For example, if there is already present in the soil sufficient available phosphorus to produce a forty-bushel crop, and the nitrogen supply or the moisture supply is sufficient for only forty bushels, or less, then extra phosphorus added to the soil cannot increase the yield beyond this forty-bushel limit.

There are several different materials containing phosphorus which are applied to land as fertilizer. The more important of these are bone meal, acid phosphate, natural raw rock phosphate, and basic slag. Obviously that carrier of phosphorus which gives the most economical returns, as considered from all standpoints, is the most suitable one to use. Altho this matter has been the subject of much discussion and investigation the question still remains unsettled. Probably there is no single carrier of phosphorus that will prove to be the most economical one to use under all circumstances because so much depends upon soil conditions, crops grown, length of haul, and market conditions.

Bone meal, prepared from the bones of animals, appears on the market in two different forms, raw and steamed. Raw bone meal contains, besides the phosphorus, a considerable percentage of nitrogen which adds a useless expense if the material is purchased for the sake of the phosphorus. As a source of phosphorus, steamed bone meal is preferable to raw bone meal. Steamed bone meal is prepared by extracting most of the nitrogenous and fatty matter from the bones, thus producing a more nearly pure form of calcium phosphate containing about 10 to 12 percent of the element phosphorus.

Acid phosphate is produced by treating rock phosphate with sulfuric acid. The two are mixed in about equal amounts; the product therefore contains about one-half as much phosphorus as the rock phosphate itself. Acid phosphate also contains besides phosphorus, sulfur, which is another plant-food element. The phosphorus in acid phosphate is more readily available for absorption by plants than that of raw rock phosphate. Acid phosphate of good quality should contain 6 percent or more of the element phosphorus.

Rock phosphate, sometimes called floats, is a mineral substance found in vast deposits in certain regions. The phosphorus in this mineral exists chemically as tri-calcium phosphate and a good grade of the rock should contain 12½ percent, or more, of the element phosphorus. The rock should be ground to a powder, fine enough to pass thru a 100-mesh sieve, or even finer.

The relative cheapness of raw rock phosphate, as compared with the treated or acidulated material, makes it possible to apply for equal money expenditure considerably more phosphorus per acre in this form than in the form of acid phosphate, the ratio being, under the market conditions of the past several years, about 4 to 1. That is to say, under these market conditions, a dollar will purchase about four times as much of the element phosphorus in the form of rock phosphate as in the form of acid phosphate, which is an important consideration if one is interested in building up a phosphorus reserve in the soil. As explained above, more very carefully conducted comparisons on various soil types under various cropping systems are needed before definite statements can be given as to which form of phosphate is most economical to use in all situations.

Basic slag, known also as Thomas phosphate, is another carrier of phosphorus that might be mentioned because of its considerable usage in Europe and eastern United States. Basic slag phosphate is a by-product in the manufacture of steel. It contains a considerable proportion of basic material and therefore it tends to influence to some extent the soil reaction.

Rock phosphate may be applied at any time during a rotation, but it is applied to the best advantage either preceding a crop of clover, which plant seems to possess an unusual power for assimilating raw phosphate, or else at a time when it can be plowed under with some form of organic matter such as animal manure or green manure, the decay of which serves to liberate the phosphorus from its insoluble condition in the rock. It is important that the finely ground rock phosphate be intimately mixed with the organic material as it is plowed under.

In using acid phosphate or bone meal in a cropping system which includes wheat, it is a common practice to apply the material in the preparation of the wheat ground. It may be advantageous, however, to divide the total amount to be used and apply a portion to the other crops of the rotation, particularly to corn and to clover.

The Potassium Problem

Our most common soils, in which clay and silt form a considerable part of the constituency, are well stocked with potassium, altho it exists largely in insoluble form. Such soils as sands and peats, however, are likely to be low in this element. On such soils this deficiency may be supplied by the application of some potassium salt, such as potassium sulfate, potassium chlorid, kainit, or other potassium compound, and in many instances this is done at great profit.

From all the facts at hand it seems, so far as our great areas of common soils are concerned, that the potassium problem is not one of addition but of liberation. The Rothamsted records, which represent the oldest soil experiment fields in the world, show that for many years other soluble salts have had practically the same power as potassium to increase crop yields in the absence of sufficient decaying organic matter. Whether this action relates to supplying or liberating potassium for its own sake, or to the power of the soluble salt to increase the availability of phosphorus or other elements, is not known, but where much potassium is removed, as in the entire crops at Rothamsted, with no return of organic residues, probably the soluble salt functions in both ways.

Further evidence on this matter is furnished by the Illinois experiment field at Fairfield, where potassium sulfate has been compared with kainit both with and without the addition of organic matter in the form of stable manure. Both sulfate and kainit produced a substantial increase in the yield of corn, but the cheaper salt—kainit—was just as effective as the potassium sulfate, and returned some financial profit. Manure alone gave an increase similar to that produced by the potassium salts, but the salts added to the manure gave very little increase over that produced by the manure alone. This is explained in part perhaps because the potassium removed in the crops is mostly returned in the manure if properly cared for, and perhaps in larger part because the decaying organic matter helps to liberate and hold in solution other plant-food elements, especially phosphorus.

In laboratory experiments at the Illinois Experiment Station, it has been shown that potassium salts and most other soluble salts increase the solubility of the phosphorus in soil and in rock phosphate; also that the addition of glucose with rock phosphate in pot-culture experiments increases the availability of the phosphorus, as measured by plant growth, altho the glucose consists only of carbon, hydrogen, and oxygen, and thus contains no plant food of value.

In considering the conservation of potassium on the farm it should be remembered that in average live-stock farming the animals destroy two-thirds of the organic matter and retain one-fourth of the nitrogen and phosphorus from the food they consume, but that they retain less than one-tenth of the potassium; so that the actual loss of potassium in the products sold from the farm, either in grain farming or in live-stock farming, is negligible on land containing 25,000 pounds or more of potassium in the surface 6⅔ inches.

The Calcium and Magnesium Problem

When measured by the actual crop requirements for plant food, magnesium and calcium are more limited in some Illinois soils than potassium. But with these elements we must also consider the loss by leaching.

Doctor Edward Bartow and associates, of the Illinois State Water Survey, have shown that as an average of 90 analyses of Illinois well-waters drawn chiefly from glacial sands, gravels, or till, 3 million pounds of water (about the average annual drainage per acre for Illinois) contained 11 pounds of potassium, 130 of magnesium, and 330 of calcium. These figures are very significant, and it may be stated that if the plowed soil is well supplied with the carbonates of magnesium and calcium, then a very considerable proportion of these amounts will be leached from that stratum. Thus the loss of calcium from the plowed soil of an acre at Rothamsted, England, where the soil contains plenty of limestone, has averaged more than 300 pounds a year as determined by analyzing the soil in 1865 and again in 1905. And practically the same amount of calcium was found by analyzing the Rothamsted drainage waters.

The annual loss of limestone from the soil depends, of course, upon a number of factors aside from those which have to do with climatic conditions. Among these factors may be mentioned the character of the soil, the kind of limestone, its condition of fineness, the amount present, and the sort of farming practiced. Because of this variation in the loss of carbonates from the soil, it

is impossible to prescribe a fixed practice in their renewal that will apply universally. The tests described on pages 35 and 36, together with the behavior of such lime-loving legumes as alfalfa and sweet clover, will serve as general indicators for the frequency of applying limestone and the amount to use on a given field.

It is of interest to note that thirty crops of clover of 4 tons each would require 3,510 pounds of calcium, while the most common prairie land of southern Illinois contains only 3,420 pounds of total calcium in the plowed soil of an acre. Thus limestone has a positive value on some soils for the plant food which it supplies, in addition to its value in correcting soil acidity and in improving the physical condition of the soil. Ordinary limestone (abundant in the southern and western parts of the state) contains nearly 800 pounds of calcium per ton; while a good grade of dolomitic limestone (the more common limestone of northern Illinois) contains about 400 pounds of calcium and 300 pounds of magnesium per ton. Both of these elements are furnished in readily available form in ground dolomitic limestone.

The Sulfur Question

In considering the relation of sulfur in a permanent system of soil fertility it is important to understand something of the cycle of transformations that this element undergoes in nature. Briefly stated this is as follows:

Sulfur exists in the soil in both organic and inorganic forms, the former being gradually converted to the latter form thru bacterial action. In this inorganic form sulfur is taken up by plants which in their physiological processes change it once more into an organic form as a constituent of protein. When these plant proteins are consumed by animals, the sulfur becomes a part of the animal protein. When these plant and animal proteins are decomposed, either thru bacterial action, or thru combustion, as in the burning of coal, the sulfur passes into the atmosphere or into the soil solution in the form of sulfur dioxid gas. This gas unites with oxygen and water to form sulfuric acid, which is readily washed back into the soil by the rain, thus completing the cycle, from soil—to plants and animals—to air—to soil.

In this way sulfur becomes largely a self-renewing element of the soil, altho there is a considerable loss from the soil by leaching. Observations taken at the Illinois Agricultural Experiment Station show that 40 pounds of sulfur per acre are brought into the soil thru the annual rainfall. With a fair stock of sulfur, such as exists in our common types of soil, and with an annual return, which of itself would more than suffice for the needs of maximum crops, the maintenance of an adequate sulfur supply presents little reason at present for serious concern. There are regions, however, where the natural stock of sulfur in the soil is not nearly so high and where the amount returned thru rainfall is small. Under such circumstances sulfur soon becomes a limiting element of crop production, and it will be necessary sooner or later to introduce this substance from some outside source. Investigation is now under way to determine to what extent this situation may apply to conditions in Illinois.

Physical Improvement of Soils

In the management of most soil types, one very important thing, aside from proper fertilization, tillage, and drainage, is to keep the soil in good physical condition, or good tilth. The constituent most important for this purpose is organic matter. Organic matter in producing good tilth helps to control washing of soil on rolling land, raises the temperature of drained soil, increases the moisture-holding capacity of the soil, retards capillary rise and consequently loss of moisture by surface evaporation, and helps to overcome the tendency of some soils to run together badly.

The physical effect of organic matter is to produce a granulation or mellowness, by cementing the fine soil particles into crumbs or grains about as large as grains of sand, which produces a condition very favorable for tillage, percolation of rainfall, and the development of plant roots.

Organic matter is being destroyed during a large part of the year and the nitrates produced in its decomposition are used for plant growth. Altho this decomposition is necessary, it nevertheless reduces the amount of organic matter, and provision must therefore be made for maintaining the supply. The practical way to do this is to turn under the farm manure, straw, corn stalks, weeds, and all or part of the legumes produced on the farm. The amount of legumes needed depends upon the character of the soil. There are farms, especially grain farms, in nearly every community where all legumes could be turned under for several years to good advantage.

Manure should be spread upon the land as soon as possible after it is produced, for if it is allowed to lie in the barnyard several months as is so often the case, from one-third to two-thirds of the organic matter will be lost.

Straw and corn stalks should be turned under, and not burned. Probably no form of organic matter acts more beneficially in producing good tilth than corn stalks. It is true, they decay rather slowly, but it is also true that their durability in the soil is exactly what is needed in the production of good tilth. Furthermore, the nitrogen in a ton of corn stalks is one and one-half times that of a ton of manure, and a ton of dry corn stalks incorporated in the soil will ultimately furnish as much humus as four tons of average farm manure. When burned, however, both the humus-making material and the nitrogen are lost to the soil.

It is a common practice in the corn belt to pasture the corn stalks during the winter and often rather late in the spring after the frost is out of the ground. This tramping by stock sometimes puts the soil in bad condition for working. It becomes partially puddled and will be cloddy as a result. If tramped too late in the spring, the natural agencies of freezing and thawing and wetting and drying, with the aid of ordinary tillage, fail to produce good tilth before the crop is planted. Whether the crop is corn or oats, it necessarily suffers, and if the season is dry, much damage may be done. If the field is put in corn, a poor stand is likely to result, and if put in oats, the soil is so compact as to be unfavorable for their growth. Sometimes the soil is worked when too wet. This also produces a partial puddling which is unfavorable to physical, chemical, and biological processes. The effect becomes worse if cropping has reduced the organic matter below the amount necessary to maintain good tilth.

Systems of Crop Rotations

In a program of permanent soil improvement one should adopt at the outset a good rotation of crops, including a liberal use of legumes, in order to increase the organic matter of the soil either by plowing under the legume crops and other crop residues (straw and corn stalks), or by using for feed and bedding practically all the crops raised and returning the manure to the land with the least possible loss. No one can say in advance for every particular case what will prove to be the best rotation of crops, because of variation in farms and farmers and in prices for produce.

Following are a few suggested rotations, applicable to the corn belt, which may serve as models or outlines to be modified according to special circumstances.

Six-Year Rotations

First year —Corn
Second year —Corn
Third year —Wheat or oats (with clover, or clover and grass)
Fourth year —Clover, or clover and grass
Fifth year —Wheat (with clover), or grass and clover
Sixth year —Clover, or clover and grass

Of course there should be as many fields as there are years in the rotation. In grain farming, with small grain grown the third and fifth years, most of the unsalable products should be returned to the soil, and the clover may be clipped and left on the land or returned after threshing out the seed (only the clover seed being sold the fourth and sixth years); or, in live-stock farming, the field may be used three years for timothy and clover pasture and meadow if desired. The system may be reduced to a five-year rotation by cutting out either the second or the sixth year, and to a four-year system by omitting the fifth and sixth years, as indicated below.

Five-Year Rotations

First year —Corn
Second year —Wheat or oats (with clover, or clover and grass)
Third year —Clover, or clover and grass
Fourth year —Wheat (with clover), or clover and grass
Fifth year —Clover, or clover and grass

First year —Corn
Second year —Corn
Third year —Wheat or oats (with clover, or clover and grass)
Fourth year —Clover, or clover and grass
Fifth year —Wheat (with clover)

First year —Corn
Second year —Cowpeas or soybeans
Third year —Wheat (with clover)
Fourth year —Clover
Fifth year —Wheat (with clover)

The last rotation mentioned above allows legumes to be seeded four times. Alfalfa may be grown on a sixth field for five or six years in the combination rotation, alternating between two fields every five years, or rotating over all the fields if moved every six years.

Four-Year Rotations

First year —Wheat (with clover)
Second year —Corn
Third year —Oats (with clover)
Fourth year —Clover

First year —Corn
Second year —Corn
Third year —Wheat or oats (with clover)
Fourth year —Clover

First year —Corn
Second year —Wheat or oats (with clover)
Third year —Clover
Fourth year —Wheat (with clover)

First year —Wheat (with clover)
Second year —Clover
Third year —Corn
Fourth year —Oats (with clover)

First year —Corn
Second year —Cowpeas or soybeans
Third year —Wheat (with clover)
Fourth year —Clover

Alfalfa may be grown on a fifth field for four or eight years, which is to be alternated with one of the four; or the alfalfa may be moved every five years, and thus rotated over all five fields every twenty-five years.

Three-Year Rotations

First year —Corn
Second year —Oats or wheat (with clover)
Third year —Clover

First year —Wheat (with clover)
Second year —Corn
Third year —Cowpeas or soybeans

By allowing the clover, in the last rotation mentioned, to grow in the spring before preparing the land for corn, we have provided a system in which legumes grow on every acre every year. This is likewise true of the following suggested two-year system:

Two-Year Rotations

First year —Oats or wheat (with sweet clover)
Second year —Corn

Altho in this two-year rotation either oats or wheat is suggested, as a matter of fact, by dividing the land devoted to small grain, both of these crops can be grown simultaneously, thus providing a three-crop system in a two-year cycle.

It should be understood that in all of the above suggested cropping systems it may be desirable in some cases to substitute rye for the wheat or oats. In all of these proposed rotations the word *clover* is used in a general sense to designate either red clover, alsike clover, or sweet clover. The value of sweet clover especially as a green manure for building up depleted soils, as well as a pasture and hay-crop, is becoming thoroly established, and its importance in a crop-rotation program may well be emphasized.

SUPPLEMENT: EXPERIMENT FIELD DATA

(Results from Experiment Fields Representing the More Important Types of Soil Occurring in Livingston County)

In the earlier reports of this series it was the practice to incorporate in the body of the report the results of certain experiment fields, for the purpose of illustrating the possibilities of improving the soil of various types. The information carried by such data must, naturally, be considered more or less tentative. As the fields grow older new facts develop, which in some instances may call for the modification of former recommendations. It has therefore seemed desirable to separate this experiment field data from the more permanent information of the soil survey, and embody the same in the form of a supplement to the soil report proper, thus providing a convenient arrangement for possible future revisions as further data accumulate.

The University of Illinois has conducted altogether about fifty soil experiment fields in different sections of the state and on various types of soil. Altho some of these fields have been discontinued, the large majority are still in operation. It is the present purpose to report the summarized results from certain of these fields which are representative of the types of soil described in the accompanying soil report.

A few general explanations at this point, which apply to all the fields, will relieve the necessity of numerous repetitions in the following pages.

Size and Arrangement

These fields vary in size from less than two acres up to 40 acres or more. They are laid off into series of plots, the plots commonly being either one-fifth or one-tenth acre in area. Each series is occupied by one kind of crop. Usually there are several series so that a crop rotation can be carried on with every crop represented every year.

Farming Systems

On many of the fields the treatment provides for two distinct systems of farming, live-stock farming and grain farming.

In the live-stock system, stable manure is used to furnish organic matter and nitrogen. The amount applied to a plot is based upon the amount that can be produced from crops raised on that plot.

In the grain system no animal manure is used. The organic matter and nitrogen are applied in form of plant manures, including all the plant residues produced, such as corn stalks, straw from wheat, oats, clover, etc., along with leguminous catch crops plowed under. It is the plan in this latter system to remove from the land, in the main, only the grain and seed produced, except in the case of alfalfa, that crop being harvested for hay the same as in the live-stock system.

Crop Rotations

Crops which are of interest in the respective localities are grown in definite rotations, and on most of the fields provision is made so that every crop in the rotation is represented every year. The most common rotation used is wheat, corn, oats, and clover; and often these crops are accompanied by alfalfa growing

on a fifth series. In the grain system a legume catch crop, usually sweet clover, is included, which is seeded on the young wheat in the spring and plowed under in the fall or in the following spring in preparation for corn. If the red clover crop fails, soybeans are substituted.

Soil Treatment

The treatment applied to the plots has, for the most part, been standardized according to a rather definite system, altho deviations from this system occur now and then, particularly in the older fields.

Following is a brief explanation of this standard system of treatment.

Animal Manures.—Animal manures, consisting of excreta from animals, with stable litter, are spread upon the respective plots in amounts proportionate to previous crop yields, the applications being made in the preparation for corn.

Plant Manures.—Crop residues produced on the land, such as stalks, straw, and chaff, are returned to the soil, and in addition a green-manure crop of sweet clover is seeded in small grains to be plowed under in preparation for corn. (On plots where limestone is lacking the sweet clover seldom survives.) This practice is designated as the *residues system.*

Mineral Manures.—The yearly acre-rates of application have been: for limestone, 1,000 pounds; for raw rock phosphate, 500 pounds; and for potassium, the equivalent of 200 pounds of kainit. The initial application of limestone has usually been 4 tons per acre.

Explanation of Symbols Used

0 = Untreated land or check plots
M = Manure (animal)
R = Residues (from crops, and includes legumes used as green manure)
L = Limestone
P = Phosphorus
K = Potassium (usually in the form of kainit)
N = Nitrogen (usually in the form contained in dried blood)
( ) = Parentheses enclosing figures signify tons of hay, as distinguished from bushels of seed

In discussions of this sort of data, financial profits or los
assigned market values are frequently considered. However,
erratic fluctuations in market values—especially in the past few
futile to attempt to set any prices for this purpose that are at
The yields are therefore presented with the thought that with
hand the financial returns from a given practice can readily be
the basis of any set of market values that the reader may choose

BROWN SILT LOAM

Several experiment fields have been conducted on brown silt loam soil at various locations in Illinois. Those located at the University have been in operation the longest and they serve well to illustrate the principles involved in the maintenance and improvement of this type of soil.

The Morrow Plots

It happens that the oldest soil experiment field in the United States is located on typical brown silt loam of the early Wisconsin glaciation, on the campus of the University of Illinois. This field was started in 1879 by George E. Morrow, who for many years was Professor of Agriculture, and these plots are known as the Morrow plots.

The Morrow series now consists of three plots divided into halves and the halves are subdivided into quarters. On one plot corn is grown continuously; on the second corn and oats are grown in rotation; and on the third, corn, oats, and clover are rotated. The north half of each plot has had no fertilizing material applied from the beginning of the experiments, while the south half has been treated since 1904, receiving standard applications of farm manure with cover crops grown in the one-crop and two-crop systems. Phosphorus has been applied in two different forms: rock phosphate to the southwest quarter at the rate of 600 pounds, and steamed bone meal to the southeast quarter at the rate of 200 pounds per acre per year up to 1919, when the rock phosphate was increased sufficiently to bring up the total amount applied to four times the quantity of bone meal applied. At the same time the rate of subsequent application of both forms of phosphorus was reduced to one-fourth the quantity, or to 200 pounds of rock phosphate and 50 pounds of bone meal per acre per year. In 1904 ground limestone was applied at the rate of 1,700 pounds per acre to the south half of each plot, and in 1918 a further application was made at the rate of 5 tons per acre with the intention of standardizing the application to the rate of 1,000 pounds of limestone per acre per year.

Table 1 gives the yearly records of the crop yields, and Table 2 presents the same in summarized form.

FIG. 1.—CORN ON THE MORROW PLOTS IN 1910

TABLE 1.—URBANA FIELD, MORROW PLOTS: BROWN SILT LOAM; PRAIRIE; EARLY WISCONSIN GLACIATION

Crop Yields in Soil Experiments—Bushels or (tons) per acre

Years	Soil treatment applied	Corn every year	Two-year rotation		Three-year rotation		
		Corn	Corn	Oats	Corn	Oats	Clover
1879–87	None........	....	....	....	....	....	....
1888	None........	54.3	49.5	....	....	48.6	....
1889	None........	43.2	....	37.4	....	....	(4.04)
1890	None........	48.7	54.3	....	....	....	(1.51)
1891	None........	28.6	33.2	....	....	....	(1.46)
1892	None........	33.1	....	37.2	70.2	....	....
1893	None........	21.7	29.6	....	34.1	....	....
1894	None........	34.8	....	57.2	....	65.1	....
1895	None........	42.2	41.6	....	....	22.2	....
1896	None........	62.3	....	34.5	....	....	....
1897	None........	40.1	47.0	....	....	....	....
1898	None........	18.1	....	....	....	....	....
1899	None........	50.1	44.4	....	53.5	....	....
1900	None........	48.0	....	41.5	....	....	....
1901	None........	23.7	33.7	....	34.3	....	....
1902	None........	60.2	....	56.3	....	54.6	....
1903	None........	26.0	35.9	....	....	....	(1.11)
1904	None........	21.5	....	17.5	55.3	....	....
1904	MLP........	17.1	....	25.3	72.7	....	....
1905	None........	24.8	50.0	....	....	42.3	....
1905	MLP........	31.4	44.9	....	....	50.6	....
1906	None........	27.1	....	34.7	....	....	(1.42)[1]
1906	MLP........	35.8	....	52.4	....	....	(1.74)[1]
1907	None........	29.0	47.8	....	80.5	....	....
1907	MLP........	48.7	87.6	....	93.6	....	....
1908	None........	13.4	....	32.9	....	40.0	....
1908	MLP........	28.0	....	45.0	....	44.4	....
1909	None........	26.6	33.0	....	....	....	(.65)[2]
1909	MLP........	31.6	64.8	....	....	....	(1.73)[3]
1910	None........	35.9	....	33.8	58.6	....	....
1910	MLP........	54.6	....	59.4	83.3	....	....
1911	None........	21.9	28.6	....	....	20.6	....
1911	MLP........	31.5	46.3	....	....	38.0	....
1912	None........	43.2	....	55.0	....	....	16.3[1]
1912	MLP........	64.2	....	81.0	....	....	20.0[1]
1913	None........	19.4	29.2	....	33.8	....	....
1913	MLP........	32.0	25.0	....	47.8	....	....
1914	None........	31.6	....	33.6	....	39.6	....
1914	MLP........	39.4	....	58.2	....	60.4	....
1915	None........	40.0	49.0	....	....	....	24.2[1]
1915	MLP........	66.0	81.2	....	....	....	27.1[1]
1916	None........	11.2	....	37.5	27.8	....	....
1916	MLP........	10.8	....	64.7	40.6	....	....
1917	None........	40.0	48.4	....	....	68.4	....
1917	MLP........	78.0	81.4	....	....	86.9	....
1918	None........	13.6	....	27.2	....	....	(2.58)
1918	MLP........	32.6	....	59.3	....	....	(4.04)
1919	None........	24.0	30.8	....	52.2	....	....
1919	MLP........	43.4	66.2	....	70.8	....	....
1920	None........	28.2	....	37.2	....	52.2	....
1920	MLP........	54.4	....	51.6	....	69.7	....
1921	None........	19.8	30.6	....	....	....	(.26)[4]
1921	MLP........	42.2	68.4	....	....	....	(1.33)[5]

[1]Soybeans.
[2]In addition to the hay, .64 bushel of seed was harvested.
[3]In addition to the hay, 1.17 bushels of seed were harvested.
[4]In addition to the hay, .53 bushel of seed was harvested.
[5]In addition to the hay, .85 bushel of seed was harvested.

TABLE 2.—URBANA FIELD, MORROW PLOTS: GENERAL SUMMARY
Average Annual Yields—Bushels or (tons) per acre

Years	Soil treatment applied	Corn every year	Two-year rotation		Three-year rotation		
			Corn	Oats	Corn	Oats	Clover
		16 crops	*9 crops*	*6 crops*	*4 crops*	*4 crops*	*4 crops*
1888 to 1903	None........	39.7	41.0	44.0	48.0	47.6	(2.03)
		18 crops	*9 crops*	*9 crops*	*6 crops*	*6 crops*	*4 crops*
1904 to 1921	None........	26.2	38.6	34.4	51.4	43.9	(1.23)[1]
	MLP........	41.2	62.9	55.2	68.1	58.3	(2.21)[1]

[1]One crop of soybean hay.

Summarizing the data from these Morrow plots into two periods with the second period beginning in 1904 when the treatment began on the half-plots, some interesting comparisons may be made. In the first place we find in the continuous corn plot a marked decrease in the second period in the average yield of corn, amounting to one-third of the crop. In the two-year rotation there is a decrease in both corn and oats production, while the averages for the three-year system show an increase in corn yield and decreases in oats and clover. Unfortunately the numbers of crops included in these last averages are too small to warrant positive conclusions.

The increase brought about by soil treatment stands out in all cases, showing the possibility not only of restoring but also of greatly improving the productive power of this land that has been so abused by continuous cropping without fertilization.

The Davenport Plots

Another set of plots on the University campus at Urbana, forming a more extensive series than the Morrow plots, but of more recent origin, are the Davenport plots. Here each crop in the rotation is represented every year. These plots were laid out in 1895, but special soil treatment was not begun until 1901. They now comprize five series of ten plots each, and each series constitutes a "field" in a crop rotation system.

From 1901 to 1911 three of the series were in a three-year rotation system of corn, oats, and clover, while the remaining two series rotated in corn and oats. In 1911 these two systems were combined into a five-series field, with a crop rotation of wheat, corn, oats, and clover, with alfalfa on a fifth field. The alfalfa occupies one series during a rotation of the other four crops, shifting to another series in the fifth year, thus completing the cycle of all series in twenty-five years.

The soil treatment applied to these plots has been as follows:

Legume cover crops were seeded in the corn at the last cultivation on Plots 2, 4, 6, and 8, from 1902 to 1907, but the growth was small and the effect, if any, was to decrease the returns from the regular crops. Crop residues (**R**) have been returned to these same plots since 1907. These consist of stalks and straw, and all legumes except alfalfa hay and the seed of clover and soybeans. Beginning in 1918 a modification of the practice was made in that one cutting of the red clover crop is harvested as hay. In conjunction with these residues a catch crop of sweet clover grown with the wheat is plowed under.

TABLE 3.—URBANA FIELD, DAVENPORT PLOTS: BROWN SILT LOAM, PRAIRIE; EARLY WISCONSIN GLACIATION

Ten-Year Average Annual Yields—Bushels or (tons) per acre
1911–1920

Serial plot No.	Soil treatment applied	Corn	Oats	Wheat	Clover 5 crops	Soybeans 5 crops	Alfalfa
1	0	55.6	50.5	26.0	(2.42)	(1.47)	(2.43)
2	R	57.1	52.3	28.7	1.47[1]	19.8	(2.46)
3	M	66.3	61.9	28.2	(2.56)	(1.62)	(2.52)
4	RL	64.8	55.6	31.4	1.61[1]	20.3	(2.72)
5	ML	69.6	64.1	32.8	(2.90)	(1.67)	(3.03)
6	RLP	71.5	69.8	43.0	2.29[1]	23.5	(3.69)
7	MLP	73.0	68.6	40.0	(3.52)	(1.97)	(3.76)
8	RLPK	70.9	72.5	40.7	1.79[1]	25.5	(3.77)
9	MLPK	70.2	72.0	39.2	(3.40)	(2.20)	(3.73)
10	Mx5LPx5	65.9	71.4	40.6	(3.31)	(2.22)	(3.77)

[1]In addition to the clover seed, a crop of hay was harvested one year on Plots 2, 4, 6, and 8, yielding 2.38, 2.20, 2.54, and 2.39 tons, respectively.

Manure (**M**) was applied preceding corn, at the rate of 2 tons per acre per year in 1905, 1906, and 1907; subsequently as many tons have been applied as there have been tons of air-dry produce harvested from the respective plots.

Lime (**L**) was applied on Plots 4 to 10 at the rate per acre of 250 pounds of air-slaked lime in 1902, and 600 pounds of limestone in 1903. No further application was made until 1911, when the system of cropping was changed. Since that time applications of limestone have been made at the rate of one-half ton per acre per year.

Phosphorus (**P**) was applied on Plots 6 to 9 at the rate of 25 pounds per acre per annum in 200 pounds of steamed bone meal; but beginning with 1908 rock phosphate at the rate of 600 pounds per acre per annum was substituted for the bone meal on one-half of each of these plots. These applications continued until 1918 when adjustments were begun, first to make the rate of application of rock phosphate four times that of the bone meal, and finally to reduce the amounts of these materials to 200 pounds of rock phosphate and 50 pounds of bone meal per acre per annum. The usual practice has been to apply and plow under at one time all phosphorus and potassium required for the rotation.

Potassium (**K** = kalium) has been applied on Plots 8 and 9 in connection with the bone meal and rock phosphate, at the yearly rate of 42 pounds per acre, and mainly as potassium sulfate.

On Plot 10 about five times as much manure and phosphorus are applied as on the other plots, but this "extra heavy" treatment was not begun until 1906, only the usual amounts of lime, phosphorus, and potassium having been applied in previous years. The purpose in making these heavy applications is to try to determine the climatic possibilities in crop yields by removing the limitations of inadequate amounts of the elements of plant food.

It will be observed that the applications described above provide for the two rather distinct systems of farming already described. *The grain system,* in which animal manure is not produced and where the organic matter is provided by the direct return to the soil of all crop residues along with legumes,

is impossible to prescribe a fixed practice in their renewal that will apply universally. The tests described on pages 35 and 36, together with the behavior of such lime-loving legumes as alfalfa and sweet clover, will serve as general indicators for the frequency of applying limestone and the amount to use on a given field.

It is of interest to note that thirty crops of clover of 4 tons each would require 3,510 pounds of calcium, while the most common prairie land of southern Illinois contains only 3,420 pounds of total calcium in the plowed soil of an acre. Thus limestone has a positive value on some soils for the plant food which it supplies, in addition to its value in correcting soil acidity and in improving the physical condition of the soil. Ordinary limestone (abundant in the southern and western parts of the state) contains nearly 800 pounds of calcium per ton; while a good grade of dolomitic limestone (the more common limestone of northern Illinois) contains about 400 pounds of calcium and 300 pounds of magnesium per ton. Both of these elements are furnished in readily available form in ground dolomitic limestone.

The Sulfur Question

In considering the relation of sulfur in a permanent system of soil fertility it is important to understand something of the cycle of transformations that this element undergoes in nature. Briefly stated this is as follows:

Sulfur exists in the soil in both organic and inorganic forms, the former being gradually converted to the latter form thru bacterial action. In this inorganic form sulfur is taken up by plants which in their physiological processes change it once more into an organic form as a constituent of protein. When these plant proteins are consumed by animals, the sulfur becomes a part of the animal protein. When these plant and animal proteins are decomposed, either thru bacterial action, or thru combustion, as in the burning of coal, the sulfur passes into the atmosphere or into the soil solution in the form of sulfur dioxid gas. This gas unites with oxygen and water to form sulfuric acid, which is readily washed back into the soil by the rain, thus completing the cycle, from soil—to plants and animals—to air—to soil.

In this way sulfur becomes largely a self-renewing element of the soil, altho there is a considerable loss from the soil by leaching. Observations taken at the Illinois Agricultural Experiment Station show that 40 pounds of sulfur per acre are brought into the soil thru the annual rainfall. With a fair stock of sulfur, such as exists in our common types of soil, and with an annual return, which of itself would more than suffice for the needs of maximum crops, the maintenance of an adequate sulfur supply presents little reason at present for serious concern. There are regions, however, where the natural stock of sulfur in the soil is not nearly so high and where the amount returned thru rainfall is small. Under such circumstances sulfur soon becomes a limiting element of crop production, and it will be necessary sooner or later to introduce this substance from some outside source. Investigation is now under way to determine to what extent this situation may apply to conditions in Illinois.

Physical Improvement of Soils

In the management of most soil types, one very important thing, aside from proper fertilization, tillage, and drainage, is to keep the soil in good physical condition, or good tilth. The constituent most important for this purpose is organic matter. Organic matter in producing good tilth helps to control washing of soil on rolling land, raises the temperature of drained soil, increases the moisture-holding capacity of the soil, retards capillary rise and consequently loss of moisture by surface evaporation, and helps to overcome the tendency of some soils to run together badly.

The physical effect of organic matter is to produce a granulation or mellowness, by cementing the fine soil particles into crumbs or grains about as large as grains of sand, which produces a condition very favorable for tillage, percolation of rainfall, and the development of plant roots.

Organic matter is being destroyed during a large part of the year and the nitrates produced in its decomposition are used for plant growth. Altho this decomposition is necessary, it nevertheless reduces the amount of organic matter, and provision must therefore be made for maintaining the supply. The practical way to do this is to turn under the farm manure, straw, corn stalks, weeds, and all or part of the legumes produced on the farm. The amount of legumes needed depends upon the character of the soil. There are farms, especially grain farms, in nearly every community where all legumes could be turned under for several years to good advantage.

Manure should be spread upon the land as soon as possible after it is produced, for if it is allowed to lie in the barnyard several months as is so often the case, from one-third to two-thirds of the organic matter will be lost.

Straw and corn stalks should be turned under, and not burned. Probably no form of organic matter acts more beneficially in producing good tilth than corn stalks. It is true, they decay rather slowly, but it is also true that their durability in the soil is exactly what is needed in the production of good tilth. Furthermore, the nitrogen in a ton of corn stalks is one and one-half times that of a ton of manure, and a ton of dry corn stalks incorporated in the soil will ultimately furnish as much humus as four tons of average farm manure. When burned, however, both the humus-making material and the nitrogen are lost to the soil.

It is a common practice in the corn belt to pasture the corn stalks during the winter and often rather late in the spring after the frost is out of the ground. This tramping by stock sometimes puts the soil in bad condition for working. It becomes partially puddled and will be cloddy as a result. If tramped too late in the spring, the natural agencies of freezing and thawing and wetting and drying, with the aid of ordinary tillage, fail to produce good tilth before the crop is planted. Whether the crop is corn or oats, it necessarily suffers, and if the season is dry, much damage may be done. If the field is put in corn, a poor stand is likely to result, and if put in oats, the soil is so compact as to be unfavorable for their growth. Sometimes the soil is worked when too wet. This also produces a partial puddling which is unfavorable to physical, chemical, and biological processes. The effect becomes worse if cropping has reduced the organic matter below the amount necessary to maintain good tilth.

Systems of Crop Rotations

In a program of permanent soil improvement one should adopt at the outset a good rotation of crops, including a liberal use of legumes, in order to increase the organic matter of the soil either by plowing under the legume crops and other crop residues (straw and corn stalks), or by using for feed and bedding practically all the crops raised and returning the manure to the land with the least possible loss. No one can say in advance for every particular case what will prove to be the best rotation of crops, because of variation in farms and farmers and in prices for produce.

Following are a few suggested rotations, applicable to the corn belt, which may serve as models or outlines to be modified according to special circumstances.

Six-Year Rotations

First year —Corn
Second year —Corn
Third year —Wheat or oats (with clover, or clover and grass)
Fourth year —Clover, or clover and grass
Fifth year —Wheat (with clover), or grass and clover
Sixth year —Clover, or clover and grass

Of course there should be as many fields as there are years in the rotation. In grain farming, with small grain grown the third and fifth years, most of the unsalable products should be returned to the soil, and the clover may be clipped and left on the land or returned after threshing out the seed (only the clover seed being sold the fourth and sixth years); or, in live-stock farming, the field may be used three years for timothy and clover pasture and meadow if desired. The system may be reduced to a five-year rotation by cutting out either the second or the sixth year, and to a four-year system by omitting the fifth and sixth years, as indicated below.

Five-Year Rotations

First year —Corn
Second year —Wheat or oats (with clover, or clover and grass)
Third year —Clover, or clover and grass
Fourth year —Wheat (with clover), or clover and grass
Fifth year —Clover, or clover and grass

First year —Corn
Second year —Corn
Third year —Wheat or oats (with clover, or clover and grass)
Fourth year —Clover, or clover and grass
Fifth year —Wheat (with clover)

First year —Corn
Second year —Cowpeas or soybeans
Third year —Wheat (with clover)
Fourth year —Clover
Fifth year —Wheat (with clover)

The last rotation mentioned above allows legumes to be seeded four times. Alfalfa may be grown on a sixth field for five or six years in the combination rotation, alternating between two fields every five years, or rotating over all the fields if moved every six years.

Four-Year Rotations

First year	—Wheat (with clover)	*First year*	—Corn
Second year	—Corn	*Second year*	—Corn
Third year	—Oats (with clover)	*Third year*	—Wheat or oats (with clover)
Fourth year	—Clover	*Fourth year*	—Clover
First year	—Corn	*First year*	—Wheat (with clover)
Second year	—Wheat or oats (with clover)	*Second year*	—Clover
Third year	—Clover	*Third year*	—Corn
Fourth year	—Wheat (with clover)	*Fourth year*	—Oats (with clover)

First year	—Corn
Second year	—Cowpeas or soybeans
Third year	—Wheat (with clover)
Fourth year	—Clover

Alfalfa may be grown on a fifth field for four or eight years, which is to be alternated with one of the four; or the alfalfa may be moved every five years, and thus rotated over all five fields every twenty-five years.

Three-Year Rotations

First year	—Corn	*First year*	—Wheat (with clover)
Second year	—Oats or wheat (with clover)	*Second year*	—Corn
Third year	—Clover	*Third year*	—Cowpeas or soybeans

By allowing the clover, in the last rotation mentioned, to grow in the spring before preparing the land for corn, we have provided a system in which legumes grow on every acre every year. This is likewise true of the following suggested two-year system:

Two-Year Rotations

First year	—Oats or wheat (with sweet clover)
Second year	—Corn

Altho in this two-year rotation either oats or wheat is suggested, as a matter of fact, by dividing the land devoted to small grain, both of these crops can be grown simultaneously, thus providing a three-crop system in a two-year cycle.

It should be understood that in all of the above suggested cropping systems it may be desirable in some cases to substitute rye for the wheat or oats. In all of these proposed rotations the word *clover* is used in a general sense to designate either red clover, alsike clover, or sweet clover. The value of sweet clover especially as a green manure for building up depleted soils, as well as a pasture and hay-crop, is becoming thoroly established, and its importance in a crop-rotation program may well be emphasized.

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A few general explanations at this point, which apply to all the fields, will relieve the necessity of numerous repetitions in the following pages.

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These fields vary in size from less than two acres up to 40 acres or more. They are laid off into series of plots, the plots commonly being either one-fifth or one-tenth acre in area. Each series is occupied by one kind of crop. Usually there are several series so that a crop rotation can be carried on with every crop represented every year.

Farming Systems

On many of the fields the treatment provides for two distinct systems of farming, live-stock farming and grain farming.

In the live-stock system, stable manure is used to furnish organic matter and nitrogen. The amount applied to a plot is based upon the amount that can be produced from crops raised on that plot.

In the grain system no animal manure is used. The organic matter and nitrogen are applied in form of plant manures, including all the plant residues produced, such as corn stalks, straw from wheat, oats, clover, etc., along with leguminous catch crops plowed under. It is the plan in this latter system to remove from the land, in the main, only the grain and seed produced, except in the case of alfalfa, that crop being harvested for hay the same as in the live-stock system.

Crop Rotations

Crops which are of interest in the respective localities are grown in definite rotations, and on most of the fields provision is made so that every crop in the rotation is represented every year. The most common rotation used is wheat, corn, oats, and clover; and often these crops are accompanied by alfalfa growing

on a fifth series. In the grain system a legume catch crop, usually sweet clover, is included, which is seeded on the young wheat in the spring and plowed under in the fall or in the following spring in preparation for corn. If the red clover crop fails, soybeans are substituted.

Soil Treatment

The treatment applied to the plots has, for the most part, been standardized according to a rather definite system, altho deviations from this system occur now and then, particularly in the older fields.

Following is a brief explanation of this standard system of treatment.

Animal Manures.—Animal manures, consisting of excreta from animals, with stable litter, are spread upon the respective plots in amounts proportionate to previous crop yields, the applications being made in the preparation for corn.

Plant Manures.—Crop residues produced on the land, such as stalks, straw, and chaff, are returned to the soil, and in addition a green-manure crop of sweet clover is seeded in small grains to be plowed under in preparation for corn. (On plots where limestone is lacking the sweet clover seldom survives.) This practice is designated as the *residues system.*

Mineral Manures.—The yearly acre-rates of application have been: for limestone, 1,000 pounds; for raw rock phosphate, 500 pounds; and for potassium, the equivalent of 200 pounds of kainit. The initial application of limestone has usually been 4 tons per acre.

Explanation of Symbols Used

O = Untreated land or check plots
M = Manure (animal)
R = Residues (from crops, and includes legumes used as green manure)
L = Limestone
P = Phosphorus
K = Potassium (usually in the form of kainit)
N = Nitrogen (usually in the form contained in dried blood)
( ) = Parentheses enclosing figures signify tons of hay, as distinguished from bushels of seed

In discussions of this sort of data, financial profits or los assigned market values are frequently considered.* However, erratic fluctuations in market values—especially in the past few futile to attempt to set any prices for this purpose that are at The yields are therefore presented with the thought that with hand the financial returns from a given practice can readily be the basis of any set of market values that the reader may choos

BROWN SILT LOAM

Several experiment fields have been conducted on brown silt loam soil at various locations in Illinois. Those located at the University have been in operation the longest and they serve well to illustrate the principles involved in the maintenance and improvement of this type of soil.